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SUITABILITY OF THE PROPOSED NAVAJO RESERVOIR FOR WATER SUPPLY

Environmental Protection Agency
Dallas, Texas

December 1970

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DECEMBER, 1970

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ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE
REGION VI
DALLAS, TEXAS

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INTRODUCTION

The Oklahoma Water Resources Board requested in May 1963, that the U. S. Public Health Service, under its pollution control studies of the Arkansas and Red River, investigate the possibility of the proposed Navajo Reservoir being polluted from natural sources of salt water. Of prime concern was determining the suitability of the proposed reservoir for municipal and industrial water supply, if the major sources of salt water could be controlled.

Through a series of reorganizations in the Federal water pollution control program, responsibility for this study was transferred eventually to the Water Quality Office of the Environmental Protection Agency (EPA). During the preparation of this report the Navajo Reservoir project was made inactive and is not expected to be reactivated in the foreseeable future.

Purpose of Investigation

North Fork Red River and Elm Fork of North Fork are the two principal streams within the drainage area of the proposed Navajo Reservoir. Their flow is sustained in part by salt springs and salt water seepage that significantly affect the quality of both streams. The purpose of the report is to present the findings of a water quality investigation of the principal sources of natural brines in the Elm Fork and North Fork basins and to estimate the water quality of the proposed Navajo Reservoir if the major sources of salt water on these tributary streams could be controlled.

Area of Investigation

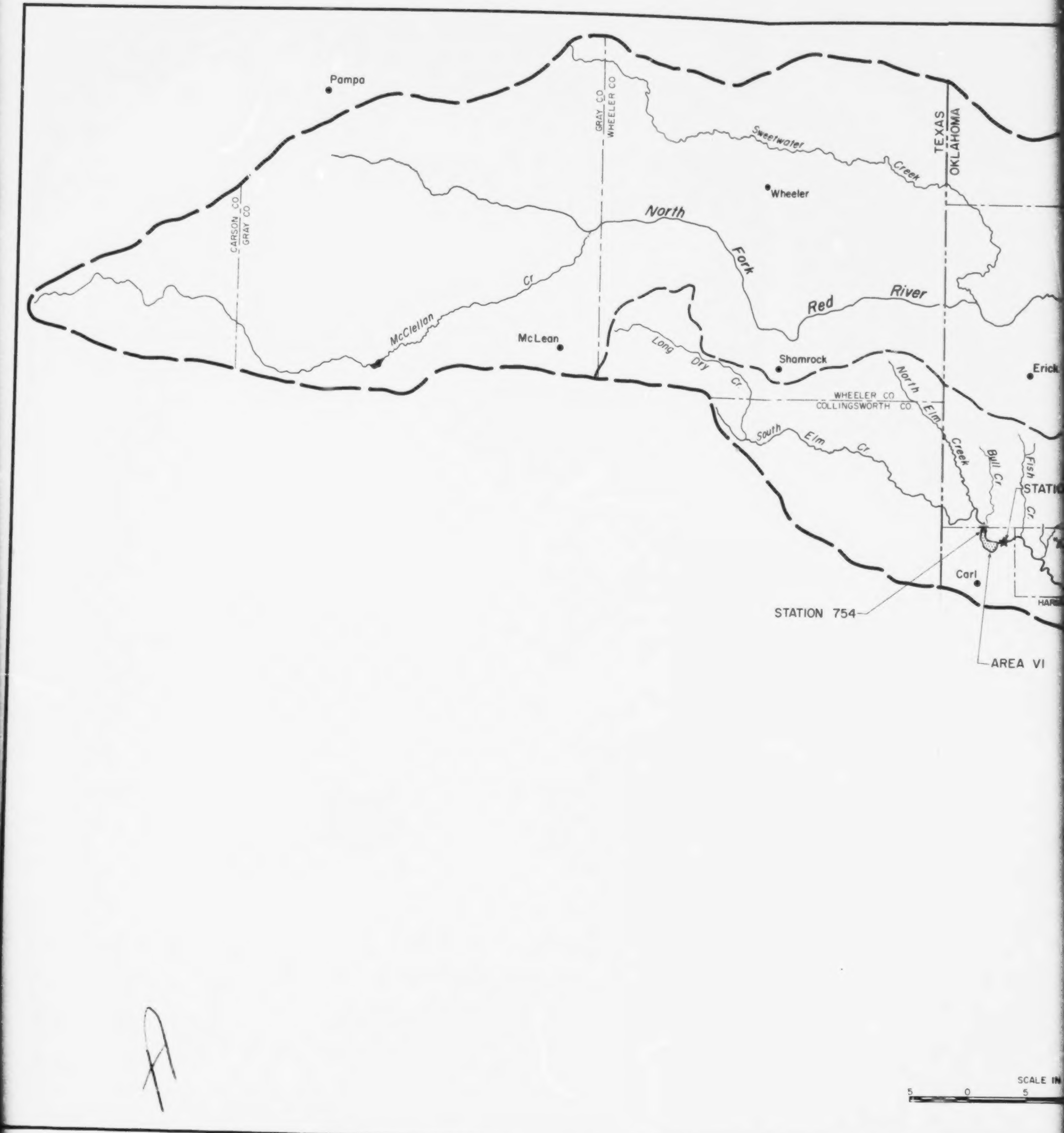
The proposed site of the Navajo Reservoir is located in southwestern Oklahoma on the lower reach of the North Fork Red River. Covering parts of Kiowa County and Jackson County, the reservoir would impound waters of the North Fork and its major tributary, Elm Fork. In addition, the reservoir would receive waters from minor streams, such as Elk Creek, from surface runoff and groundwater seepage from adjacent land and from direct preciptation. The proposed reservoir site and the basins of the North Fork and Elm Fork are shown in Figure 1.

The area of investigation extends along the North Fork from Lake Altus to Sampling Station 490 and along Elm Fork from near Bull Creek to its confluence with the North Fork. Particular emphasis was placed on Elm Fork in Area VI, so designated by the Corps of Engineers in the course of their investigation of natural salt pollution in the Arkansas-Red River basins.

Sources of Data

The basic data presented as part of this study were obtained from reports and records of the U. S. Public Health Service, the U. S. Geological Survey and from field investigations by the Federal Water Pollution Control Administration (FWPCA), a predecessor agency of the EPA. Consisting of water analyses and streamflow measurements. these data, in part, span a period ranging from July 1960 Through September 1967.

The U. S. Public Health Service initiated an intensive saline water investigation in the Arkansas-Red River basins in 1960. A network of water quality monitoring station was established of which three station were located in the North Fork and Elm Fork basins. Streamflow


Pampa
GRAY CO
WHEELER CO
CARSON CO
GRAY CO
Sweetwater
Creek
TEXAS
OKLAHOMA
Wheeler
North
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Red
River
Cr
McClellan
McLean
Long
Dry
Cr
Shamrock
Erick
North
Elm
Creek
WHEELER CO
COLLINGSWORTH CO
South
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Bull Cr
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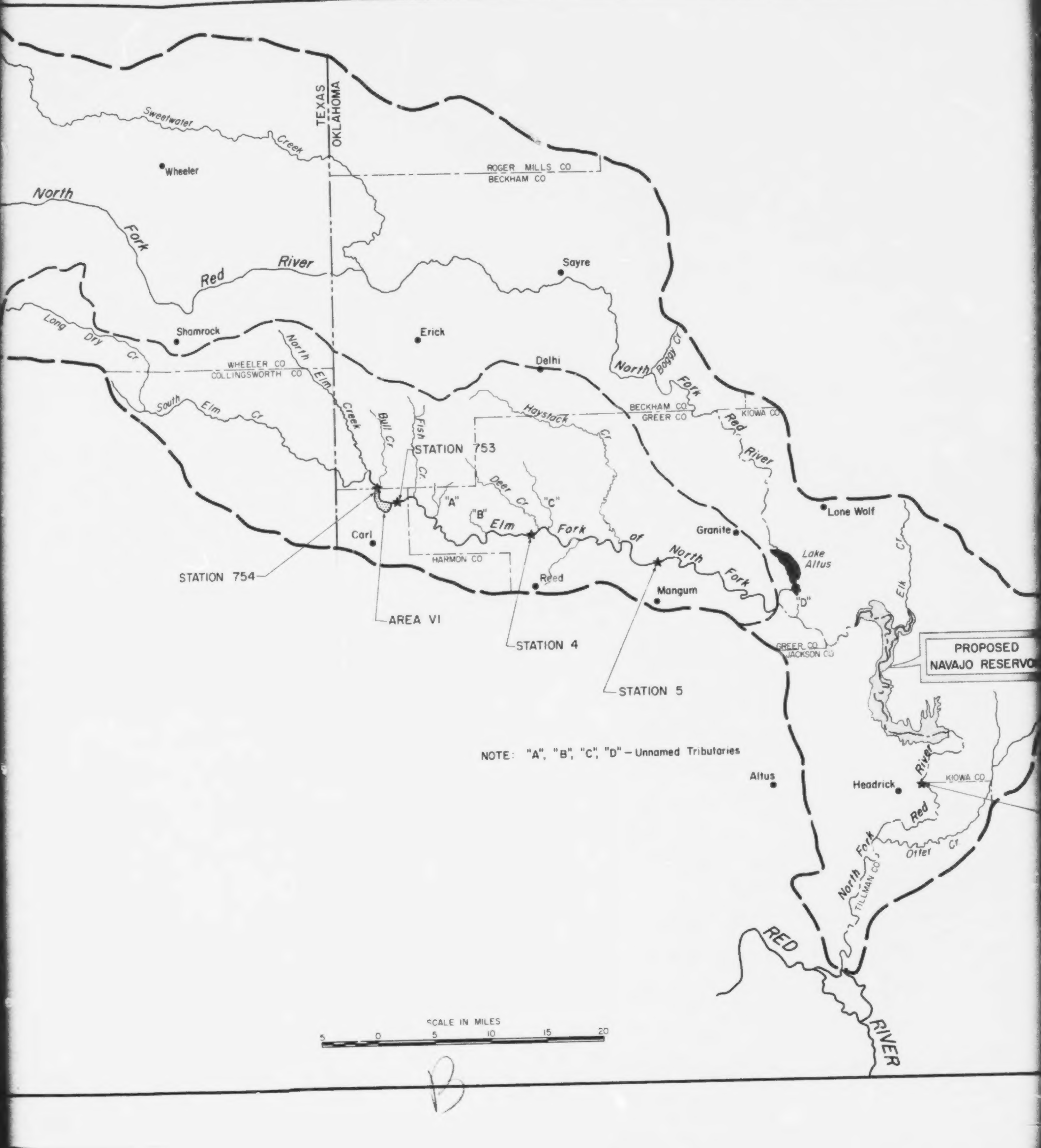
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OKLAHOMA
Sweetwater Creek
Wheeler
ROGER MILLS CO
BECKHAM CO
North Fork Red River
Sayre
Shamrock
Erick
Long Dry Cr
North Elm Creek
WHEELER CO
COLLINGSWORTH CO
Delhi
North Boggy Cr
North Fork Red River
South Elm Cr
Bull Cr
Fish Cr
Haystack Cr
BECKHAM CO
GREER CO
KIOWA CO
STATION 753
Deer Cr
"A"
"B"
"C"
Elm Fork of North Fork
Lone Wolf
Granite
Carl
Lake Altus
Elk Cr
HARMON CO
Reed
Mangum
"D"
STATION 754
AREA VI
STATION 4
STATION 5
GREER CO
JACKSON CO
PROPOSED
NAVAJO RESERVO
NOTE: "A", "B", "C", "D" – Unnamed Tributaries
Altus
Headrick
KIOWA CO
Red River
North Fork
TILLMAN CO
Otter Cr
RED RIVER
SCALE IN MILES
5
0
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10
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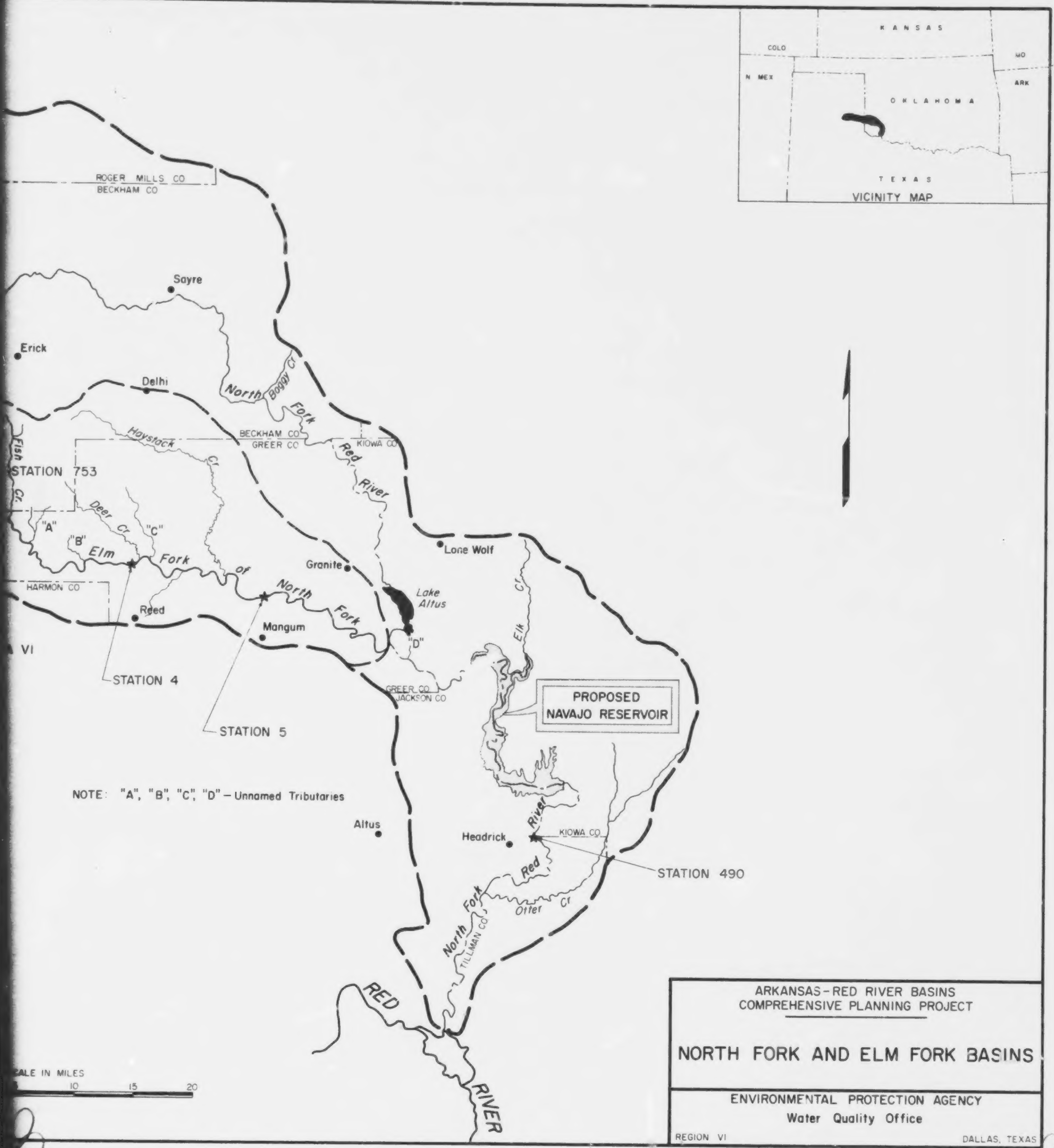
20

B


KANSAS
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Sayre
Erick
Delhi
North Boggy Cr
North Fork Red River
BECKHAM CO
GREER CO
KIOWA CO
Haystack Cr
Fish Cr
STATION 753
Deer Cr
"A"
"B"
"C"
Elm Fork of North Fork
Lone Wolf
Granite
Lake Altus
"D"
HARMON CO
Reed
Mangum
A VI
STATION 4
STATION 5
Elk Cr
GREER CO
JACKSON CO
PROPOSED NAVAJO RESERVOIR
NOTE: "A", "B", "C", "D" – Unnamed Tributaries
Altus
Headrick
KIOWA CO
STATION 490
North Fork Red River
Otter Cr
TILLMAN CO
RED RIVER
SCALE IN MILES
10
15
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ARKANSAS-RED RIVER BASINS
COMPREHENSIVE PLANNING PROJECT

NORTH FORK AND ELM FORK BASINS

ENVIRONMENTAL PROTECTION AGENCY
Water Quality Office

REGION VI DALLAS, TEXAS

FIGURE

measurements were required as part of this U. S. Public Health Service investigation and wherever possible, the water quality monitoring stations were located at existing U. S. Geological Survey streamflow gaging stations.

The FWPCA, in continuing the original U. S. Public Health Service investigation, conducted a reconnaissance field survey to determine where additional water quality monitoring stations should be located in the study area. On the basis of this field survey two stations (Stations 4 and 5) were established on Elm Fork. Temporary continuous streamflow gaging stations were installed at these stations and operated, under contract, by the U. S. Geological Survey.

FINDINGS AND CONCLUSIONS

Findings on the sources of chloride and sulfate brines in the watershed of the Navajo Reservoir, and conclusions regarding the estimated quality of the reservoir and its suitability as a source of water supply are presented in the paragraphs that follow.

Sources of Natural Brines

1. Chloride brines in the drainage area above the Navajo Reservoir occur predominently in Area VI. An average chloride loading of 322 tons per day is discharged from Area VI. This loading constitutes 72 percent of the average total daily chloride loading of the North Fork near the proposed reservoir site (Sampling Station 490).
2. Sulfate brines are distributed generally throughout the drainage area above the Navajo Reservoir. An average sulfate loading of 12 tons per day is discharged from Area VI. This loading constitutes 4 percent of the average total daily sulfate loading of the North Fork near the proposed reservoir site (Sampling Station 490).

3. The flow-weighted average chloride and sulfate concentrations of the North Fork Red River at Sampling Station 490 were 655 mg/l and 455 mg/l, respectively, for the seven year period of field investigations.

4. Calculations indicate the evaporation from the reservoir will cause large increases in the mineral concentration of the impounded water.

Estimated Quality of the Proposed Navajo Reservoir

1a. The cumulative average chloride concentration of the Navajo Reservoir, without control of brine discharges from Area VI, is estimated at 1,270 mg/l.

1b. With 80 percent control of brine discharges from Area VI, the cumulative average chloride concentration of the reservoir is estimated at 540 mg/l.

1c. With 100 percent control of brine discharges from Area VI, the cumulative average chloride concentration of the reservoir is estimated at 355 mg/l.

2a. The cumulative average sulfate concentration of the Navajo Reservoir, without control of brine discharges from Area VI, is estimated at 760 mg/l.

2b. With 80 percent control of brine discharges from Area VI, the cumulative average sulfate concentration of the reservoir is estimated at 735 mg/l.

2c. With 100 percent control of brine discharges from Area VI, the cumulative average sulfate concentration of the reservoir is estimated at 730 mg/l.

Suitability of the Navajo Reservoir as a Source of Water Supply

Municipal Supply

The estimated chloride concentrations of the reservoir with 80 percent control of Area VI, preclude its use for municipal water supply.

The estimated sulfate concentrations of the reservoir, with 80 percent control of Area VI, preclude its use for municipal water supply.

Industrial Supply

The estimated cumulative average chloride concentrations of the Navajo Reservoir, with 80 percent control of Area VI, are within the quality limits for process water used in the petroleum industry, for boiler makeup water and for those industries where brackish water can be used as cooling water in once-through systems and in the makeup recycle. The estimated chloride concentrations exceed the maximum for process water in the pulp and paper industry. For process water used in primary metals industry and for fresh cooling water in the once-through system and in the makeup water, the reservoir is of marginal quality. However, the cumulative averages do not reflect the large fluctuations in quality that frequently exceed the maximum limits of these water uses. Although periods of satisfactory reservoir quality do occur, these periods are temporary. The reliability of the reservoir quality is low. Standard deviations, based upon the yearly average concentrations for the three sets of 50-year projected reservoir use, are 135 mg/l for chloride and 185 mg/l for sulfate under 80 percent control of Area VI. As a source of industrial supply, the Navajo Reservoir is definitely unsuitable for a number of industries, is inherently inadequate for those having maximum limits of chloride concentrations that are near the cumulative average in the reservoir, and is suitable only for boiler makeup water and for brackish cooling water.

The estimated cumulative average sulfate concentrations of the Navajo Reservoir, without control, or with 80 percent control of Area VI, are within the maximum limits for boiler makeup water and for those industries where brackish water can be used for cooling in once-through systems and in the makeup recycle, and in process water in some chemical industries. The estimated sulfate concentrations exceed the maximums for fresh cooling water and for process water in the petroleum industry.

Agricultural Supply - Livestock Watering

Without control of Area VI the estimated chloride concentrations in the reservoir are generally less than the maximum recommended for livestock watering.

With 80 percent control of the estimated chloride discharges from Area VI the reservoir quality is suitable for livestock watering.

Under conditions of no control to 100 percent control of Area VI, estimated sulfate concentrations in the reservoir are generally less than the maximum recommended for livestock watering.

Agricultural Supply - Irrigation

Without control of Area VI the reservoir would have a very high sodium hazard and an extremely high salinity hazard making it unsuitable as a source of irrigation water.

With 80 percent control of Area VI the reservoir would have a medium sodium hazard and a very high salinity hazard making it unsuitable as a source of irrigation water.

GEOLOGY

The natural quality of surface and groundwater is largely determined by geologic factors. Such factors include the types of rock underlying the region, the mineral composition of these rocks, their vertical and lateral sequence and extent, the size and distribution of their interconnected void spaces, regional and local structures, and the topographic relief developed upon the land surface.

The occurrence, distribution and chemical composition of the natural brines in the North Fork and Elm Fork basins are also largely determined by local and regional geologic factors. Principal among these are the sequence of rock layering (stratigraphy), the attitude of these rocks (structure) and the distribution of salt, gypsum and anhydrite beds within and beyond the area of investigation.

Stratigraphy and Structure

The study area is underlain by rocks that range in age from Precambrian to Quaternary and includes such diverse rock types as granite, shale, siltstone, sandstone, dolomite, gypsum, anhydrite, sodium-chloride salt, gravel, sand, silt and clay. Regarding the occurrence of salt springs and salt water seepage within the basins, it is the sedimentary sequence of interbedded layers of Permian shale, siltstone, sandstone, dolomite, salt, gypsum and anhydrite that is the ultimate source of the natural brines that pollute Elm Fork and North Fork. Although the Quaternary alluvium is thought to contain mostly brackish or saline water, the water quality is determined predominantly by the inflow of saline river water and seepage from the bedrock upon which the alluvium is deposited.

The stratigraphic sequence of the Permian rocks in and near the North Fork and Elm Fork basins varies in a relatively moderate degree from one location to another and with depth below land surface. However, despite the differences, the rocks are similar in general appearance and lithology over a large area of western Oklahoma and north central Texas. Where these rocks crop out they consist of red and gray gypsiferous shale, siltstone, and fine-grained sandstone containing thick beds of gypsum ($CaSO_4.2H_2O$) and anhydrite ($CaSO_4$). Most Permian rock units contain deposits of rock salt ($NaCl$).

In Table 1 is a general description of the individual Permian rock units underlying southwestern Oklahoma. Based on a compilation by the U. S. Public Health Service, these units are listed in descending order and each unit crops out at one location or another within the North Fork and Elm Fork basins. Where each unit forms the land surface, the overlying Permian rock units are consequently absent.

Major structural features affecting the Permian rocks in and near the North Fork and Elm Fork drainage basins are the Anadarko depositional basin and the Wichita Mountains uplift. The Anadarko basin trends northwestward through west central and northern Oklahoma and is deepest adjacent to the Wichita Mountains uplift in the North Fork basin. The Permian rock units slope toward the axis of this structural depression. The occurrence of salt springs and saline groundwater may be affected more by topography and the mineral composition of the rocks than the structural features.

Salt Deposits

Permian rock salt in the North Fork and Elm Fork basins occurs as massive layers, thin lenticular beds and disseminated particles. The massive layers commonly range in

Table 1

DESCRIPTION OF PERMIAN ROCK OUTCROPS IN SOUTHWESTERN OKLAHOMA

Rock Unit	General Lithology, Salt Occurrence and Approximate Thickness
Quartermaster Formation	Upper 190 feet is composed chiefly of reddish-brown, fine-grained and medium-grained sandstone and some coarse-grained sandstone and discontinuous beds of siltstone. Lower 160 feet consists of brownish-red shale and thin beds of siltstone. Not known to contain salt in this area. 350 feet thick in Beckham County.
Cloud Chief Formation	Red, fine-grained, gypsiferous sandstone, thin interbedded, silty shale and thin beds of gypsum, anhydrite, and dolomite near the top and bottom. Not known to contain salt in this area. 430 feet thick in Beckham County.
Whitehorse Group	Predominately pink and red, shaley, silty, fine-grained sandstone and siltstone and a few irregular thin beds of gypsum and dolomite. Not known to contain salt in this area. 390 feet thick in Beckham County.
Blaine Gypsum	Massive, white beds of gypsum interbedded with red and gray gypsiferous shale. Dolomite beds underlie the gypsum beds locally. In some localities gypsum makes up 70 percent of the total thickness. Salt springs issue from the formation in southwest Beckham and southern Jackson Counties. 140 feet thick in Beckham County.
Dog Creek Shale	Predominately red, brown, and green, silty, blocky shale and thin dolomite. Locally shale is dolomitic and sandy. Contains small amount of salt in parts of southwestern Oklahoma. 80 feet thick in Beckham County.

Table 1 (Cont'd)

Rock Unit	General Lithology, Salt Occurrence, and Approximate Thickness
Flowerpot Shale	Red, brown, and maroon, silty, blocky, gypsiferous shale characterized by intersecting veins of satin spar and selenite crystals. Salt occurs within 30 feet of the surface locally in northern Harmon County. Salt springs issue from the formation in several localities in southwestern Oklahoma. 160 feet thick in Beckham County. Partially underlain by Duncan Sandstone.
Hennessey Shale	Yellowish-gray, buff, and red, blocky shale, and a few thin, fine-grained, calcareous sandstones. Not known to contain salt in this area. 850 feet thick in central-western Oklahoma.
Wichita Formation	Equivalent to the Garber Sandstone and Wellington Formation. Generally red-brown shale, siltstone, sandstone, impure limestone, and anhydrite. Contains stringers of salt locally.

Source: Oklahoma Geological Survey, U. S. Geological Survey, Unitersity of Oklahoma, Oklahoma Planning and Resources Board, Geological Congress, XXI Session.

thickness from 100 to 200 feet, but generally occur at depths of more than 500 feet below land surface. These layers are not extensive and form salt zones consisting of isolated or interfingering layers that occur more abundantly than other rock types within the zone. Thin, lenticular beds occur uncommonly at depths less than 500 feet below land surface. Disseminated particles of rock salt are thought to occur throughout much of the Permian rock sequence, except near land surface where leaching has largely removed the rock salt.

Gypsum and Anhydrite

Gypsum and anhydrite occur throughtout much of the upper part of the Permian rock sequence of the North Fork and Elm Fork basins. Of the eight Permian rock units that crop out in the area of investigation, the Blaine Gypsum and the Flowerpot Shale comprise the largest and most extensive beds of gypsum and anhydrite in the basin.

The Blaine Gypsum consists mainly of white, massive gypsum beds interbedded with red gypsiferous shale. Locally the gypsum beds are underlain by thin dolomite. The solvent action of water has developed numerous solution cavities such as sinkholes and caves. Where the Blaine Gypsum is not exposed to direct weathering and erosion but is covered by overlying rock, the Blaine Gypsum consists principally of dense anhydrite of low permeability.

The Flowerpot Shale consists principally of red and gray gypsiferous shale containing rock salt in the subsurface. This unit characteristically has numerous thin intersecting veins of selenite (clear transparent gypsum). The overall permeability of the Flowerpot Shale varies markedly within short distances.

HYDROLOGY

Precipitation

The ultimate source of water for impoundment in the proposed Navajo Reservoir is precipitation. Occurring principally as rain and snow, the average annual precipitation in the North Fork and Elm Fork basins is approximately 25 inches of which 24 inches are rain and 1 inch is snow (in water equivalency). Rainwater and snowmelt are dispersed by surface runoff, percolation into soil and rock, evaporation and transpiration.

Surface Runoff

The dispersal of rainfall and melt water as surface runoff results in rock particles being carried in solution or suspension into ditches, creeks, rivers, ponds, lakes, impoundments and other natural or manmade water bodies. These substances affect the quality of the receiving waters. Prolonged leaching of soil and bedrock has resulted in the removal of rock salt from the upper part of the exposed bedrock. As a result, shallow groundwater in the upland areas of the basins is potable. Leaching of gypsum and anhydrite beds in the outcrop areas of the Blaine Gypsum, in particular, has developed innumerable solution openings including sinkholes, and enlarged fracture openings permitting the storage and movement of groundwater. Thus, the solvent effect of rainwater acting upon the exposed rock has increased groundwater recharge of the units affected.

Groundwater Movement

The direction of groundwater movement in the zone of saturation is in response to the influence of gravity. During the process of groundwater replenishment, rainfall, snowmelt and influent seepage from surface water bodies percolate into soil and rock. Movement of groundwater is from areas of recharge to areas of discharge. Water level contour maps indicate the configuration of the water table of unconfined groundwater or the pressure surface of an artesian system. Theoretically groundwater moves at right angles to the contour lines from higher to lower elevations.

Rates of groundwater movement depend on the permeability of the rock units containing the water and the gradient of the water table or artesian pressure surface. Where rocks are more permeable, the movement of water is comparatively free, although the rate of movement is very slow in comparison to the flow of streams.

The void spaces in soil and rock ultimately control the underground movement of water. In the Permian units that contribute water to the streams of the North Fork basin, the voids in the Blaine Gypsum, for example, consist of solution channels, sinkholes and small cave-like openings. The permeability is comparatively high in this rock unit. In the Flowerpot Shale the voids of the shale rock itself are extremely small and water moves very slowly through this part of the formation. However, the Flowerpot Shale contains fractures and numerous veins of selenite, which when leached from the formation permit the collection and movement of relatively small quantities of water throughout the formation.

Springs occur commonly in the middle reaches of Elm Fork in northwestern Harmon County, Oklahoma. These springs are formed where groundwater issues naturally from the Flowerpot Shale and either flows in narrow rivulets across the land surface and down the streams or flows unseen into the channel alluvial sediments and contributes to the flow of the streams by seepage. Where subsurface discharge of springs are under sufficiently high hydrostatic pressure, the spring water may rise locally to the surface through the alluvial sediments and flow visibly across the valley floor to the stream channels.

Seepage occurs where groundwater oozes naturally from rock and issues either at the land surface or directly into surface water bodies such as streams, ditches, ponds, lakes and impoundments. Whereas springs flow forth from discrete openings more or less observable, seepage often occurs from a myriad of extremely minute openings wetting larger areas of rock surface and often forming no discernible flow channel leading from the seepage area. Subsurface seepage of groundwater through the bedrock voids directly in the channel alluvium and through the alluvium into the stream channels is the unseen, but no less important way to which groundwater is discharged in the North Fork and Elm Fork basins.

Evaporation

Rainwater, snowmelt and surface waters are dispersed in part by evaporation. The North Fork and Elm Fork basins of southwestern Oklahoma lie within an area where evaporation is relatively high. For example, based on U.S. Weather Bureau studies covering the period 1946-1955, the mean annual lake evaporation was approximately 65 inches in the study area. This compares to 20 inches in extreme northern Maine to 80 inches in the Big Bend area of Texas.

The combination of high evaporation rates and strongly mineralized surface waters result in extensive accumulations of salts incrusted on stream banks, on the scattered boulders and pebbles in the channels and in and around springs and seeps. A commercial salt works in the study area uses evaporation pits for the accumulation of sodium-chloride salt which is hauled away and sold.

Evaporation from the surface of the impounded waters causes increase in mineral concentration with passage of time. This principle was considered in estimating the water quality of the proposed Navajo Reservoir.

Water dispersal through the transpiration of the natural plant coverage is not thought to be significant because southwestern Oklahoma is an area of relatively sparse natural vegetal coverage.

Streamflow

In the North Fork and Elm Fork basins streamflow is subject to considerable variation and is sustained largely by groundwater seepage. At the U. S. Geological Survey gaging station (Station 490) on the North Fork Red River near Headrick, Oklahoma, the flow record extends from April 1905 to March 1908 and from October 1937 to the present. As of September 1968, this record included extremes ranging from no flow at times in most years to 30,700 cfs on October 5, 1955 (gage height 11.50 feet). The maximum stage known was 16.1 feet sometime prior to 1927, from information by State Highway Department. Average annual discharge for 33 years of record (through water year 1968) is 315 cfs or 228,100 acre-feet per year. However, there is considerable variation in the average annual discharge.

During the reconnaissance field survey flow measurements were made at the time of stream sampling. As shown in Table 2, the principal flow during controlled discharge from Lake Altus is on Elm Fork. At the time of measurement the flow on Elm Fork was 490.5 cfs at a location one-half mile above the confluence with North Fork. The North Fork had a flow of 0.9 cfs at a location 200 yards above the confluence with Elm Fork.

Table 2

SELECTED STREAMFLOW AND WATER-QUALITY DATA

Location	Streamflow[1] (cfs)	Specific Conductance (micromhos/cm)	Chloride Concentration (mg/l)	Chloride/Specific Conductance Ratio	Chloride Loading (T/D)
Elm Fork at Sampling Station 754	12.1	7,880	2,300	0.29	75.2
Salton Canyon	0.3	223,000	191,000	.86	154.4
Robinson Canyon	0.5	151,000	87,500	.58	118.2
Kiser Canyon	0.2	227,000	195,000	.86	105.4
Fish Creek	0.03E[2]	20,500	7,600	.37	1.0
Elm Fork, Sec. 17, T.6N., R. 25W	15.4	26,000	10,900	.42	453.7
"A" Creek[3]	0.1	146,900	125,000	.85	33.8
"B" Creek	0.1E	38,900	19,500	.50	5.3
Deer Creek	0.3	3,590	340	.10	0.3
"C" Creek	0.2	4,210	500	.12	0.3
Haystack Creek	0.5	4,320	780	.18	1.0
Elm Fork, ½ mile above confluence with North Fork	16.3	27,000	11,000	.41	490.5
North Fork, 200 yards above confluence with Elm Fork	0.5	3,350	670	.20	0.9
"D" Creek	0.4	2,030	290	.14	0.3
North Fork at Highway 283, 1½ miles below confluence with Elm Fork	18.0	25,500	10,200	.40	496.2
Elk Creek	8.5	1,450	145	.10	3.3
North Fork at Highway 62	40.5	13,000	4,550	.35	498.0

1/ All data in this table from Reconnaissance Survey, March 1965.
2/ E - Estimated.
3/ "A," "B," "C" and "D" are unnamed tributaries shown in Figure 1.

NATURAL BRINES

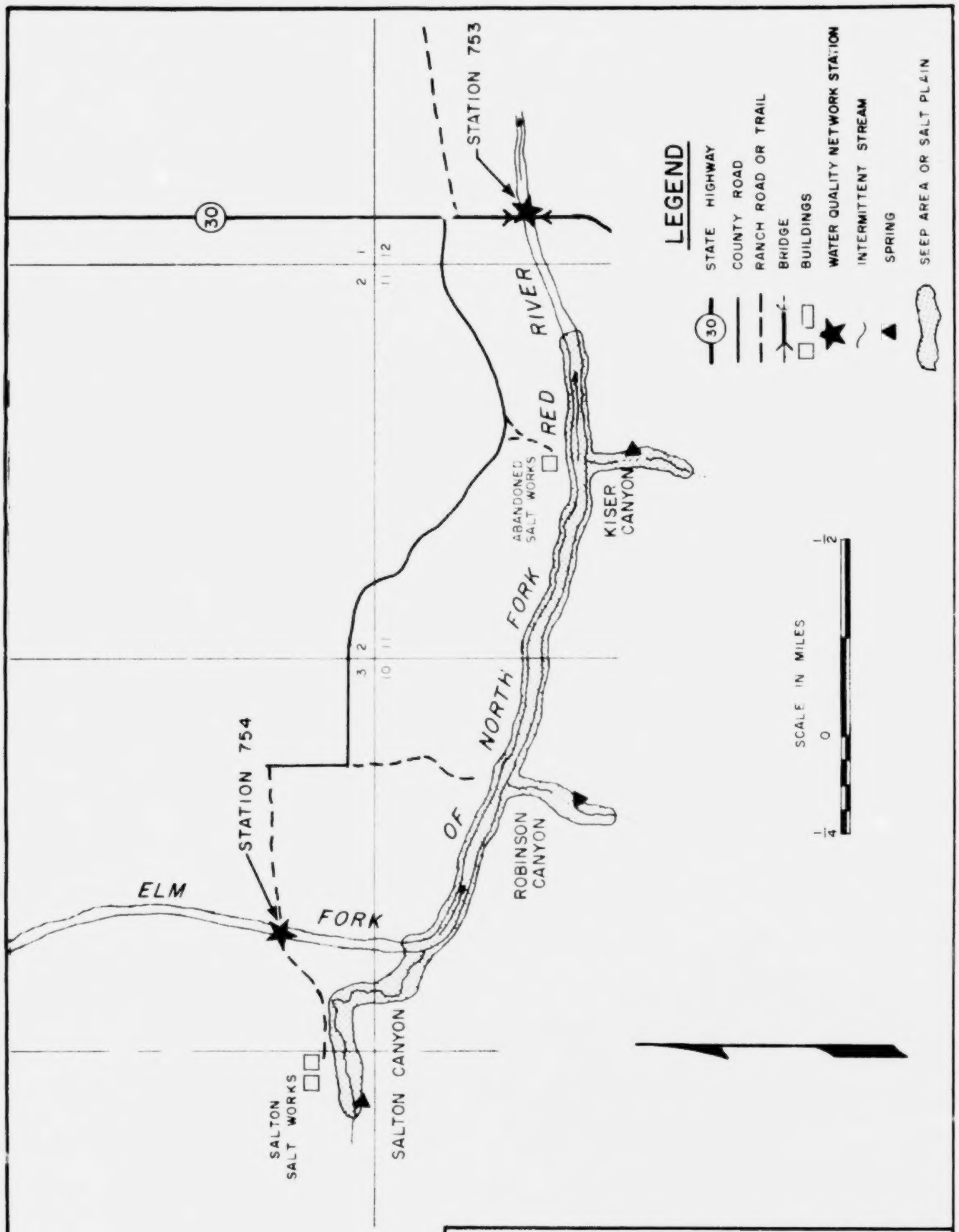
Natural brines in the Elm Fork and North Fork basins are highly mineralized groundwaters containing strong concentrations of chloride and sulfate salts. The salts are leached from rock salt deposits and from beds of gypsum and anhydrite. These brines, discharging to the streams as spring water and as seepage, together with salt water runoff and incidental effects of commercial salt recovery operations all combine to effect stream quality. From a water use standpoint, chloride, sulfate and sodium are critical constituents of water because their excessive concentration may preclude the use of the water for municipal, industrial or agricultural purposes.

The natural discharge of salt water occurs predominantly from springs and by seepage. Ove-land runoff, during and following rainfall may dilute the concentration of salts in the streams. However, following periods of evaporation and natural accumulation of salt incrustations, rainfall may result in flushing these salts into the streams to cause temporary high salt loadings.

In the discussion that follows, the water quality data are based on water samples collected in March 1965. The description of spring sites is obtained from the U. S. Geological Survey report entitled: Geology and Ground-Water Features of Salt Springs, Seeps and Plains in the Arkansas and Red River Basins of Western Oklahoma and Adjacent Parts of Kansas and Texas. A location map of Area VI showing prominent springs and seepage areas in Salton, Robinson and Kiser Canyons and along Elm Fork are shown in Figure 2. Water quality and streamflow data obtained from the Reconnaissance Survey of March 1965 are indicated in Table 2.

Elm Fork Basin

Eight tributaries of Elm Fork that have salt springs were sampled in March 1965. These streams yield the most highly mineralized chloride waters draining to the proposed Navajo Reservoir. Chloride concentrations range from a maximum of 195,000 mg/l in Kiser Canyon to a minimum of 340 mg/l in Deer Creek. Although sulfate concentrations were not determined, the chloride/specific conductance ratios strongly suggest that water containing chloride as the principal anion is discharged from four streams. Generally downstream from these tributaries the remaining tributaries


STATION 753
30
LEGEND
STATE HIGHWAY
COUNTY ROAD
RANCH ROAD OR TRAIL
BRIDGE
BUILDINGS
WATER QUALITY NETWORK STATION
INTERMITTENT STREAM
SPRING
SEEP AREA OR SALT PLAIN
RED RIVER
NORTH FORK
OF
ABANDONED SALT WORKS
KISER CANYON
SCALE IN MILES
$\frac{1}{4}$
0
$\frac{1}{2}$
STATION 754
ELM FORK
ROBINSON CANYON
SALTON SALT WORKS
SALTON CANYON
1
2
12
11
2
3
11
10

ARKANSAS—RED RIVER BASINS
COMPREHENSIVE PLANNING PROJECT

ELM FORK SALT BRINE AREA
AREA VI

ENVIRONMENTAL PROTECTION AGENCY
Water Quality Office
REGION VI DALLAS, TEXAS

FIGURE 2

contribute water in which sulfate is probably the principal anion.

The largest salt springs and seepage areas in the Elm Fork basin are in Salton, Robinson and Kiser Canyons. These canyons are located on the right bank of Elm Fork in northwestern Harmon County, Oklahoma, and are shown in Figure 2. Covering a distance of about two miles, this spring and seepage area extends from three miles east of the Texas-Oklahoma State line to one mile west of Oklahoma State Highway 30. Salt water springs flow from the Flowerpot Shale at the base of the canyon walls and from the sand-covered canyon floor. As previously indicated, this spring and seepage area is designated Area VI in the Corps of Engineers' water quality control study of the Arkansas-Red River basins and is so designated in the present report.

Photographs of salt springs in Area VI and of Salton and Kiser Canyons are shown in Figures 3, 4 and 5.

In Area VI the chloride concentrations in water sampled from Salton, Robinson and Kiser Canyons were 191,000, 87,500 and 195,000 mg/l, respectively. With one exception, these concentrations range from 4.5 to 10.0 times larger than encountered at the 13 other stations

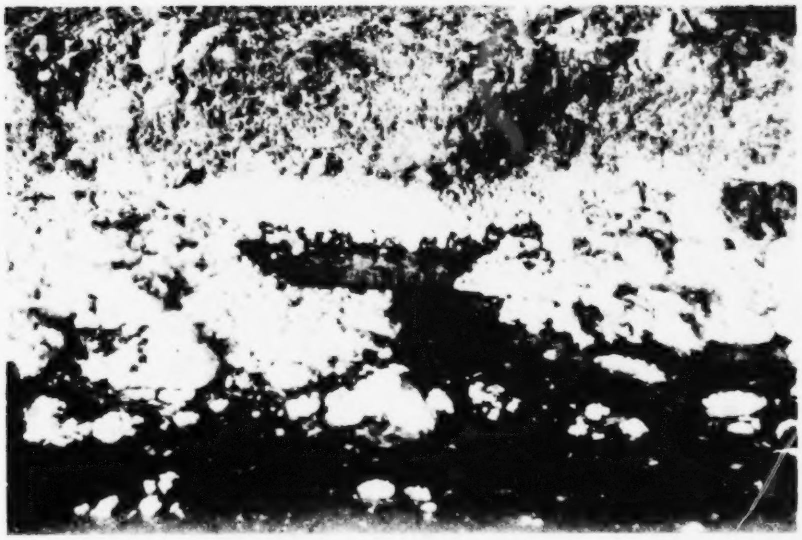
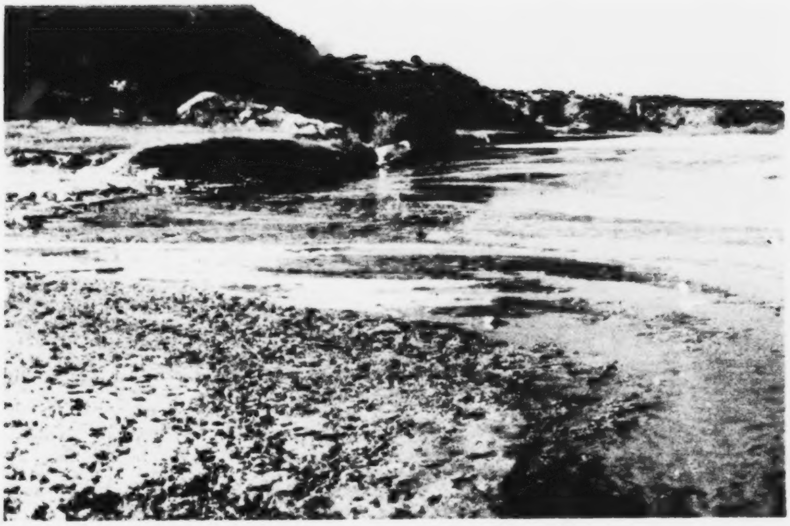


Figure 3.-Salt-water springs in Area VI, Elm Fork basin. Top, spring in Salton Canyon issuing at river's edge; bottom, spring in Kiser Canyon issuing through narrow outlet channel. Photographs by O. H. Linguist.



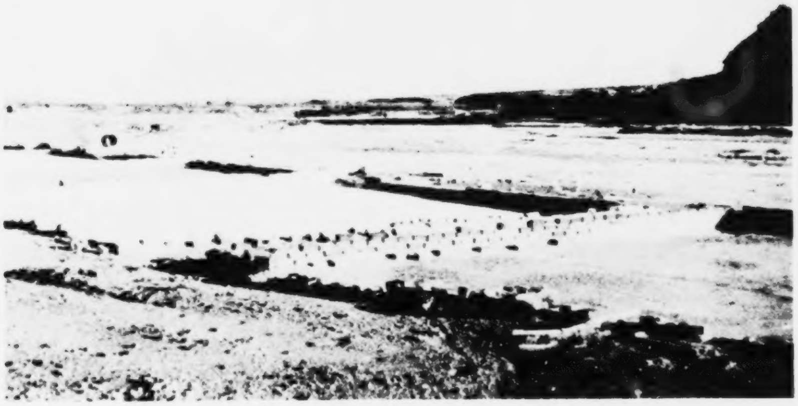


Figure 4.-Views along Elm Fork. Top, Elm Fork flowing towards foreground as it passes Kiser Canyon on the left; bottom Salton Salt Works evaporation pits in Salton Canyon. Elm Fork in distant background. Photographs by O. H. Linguist.

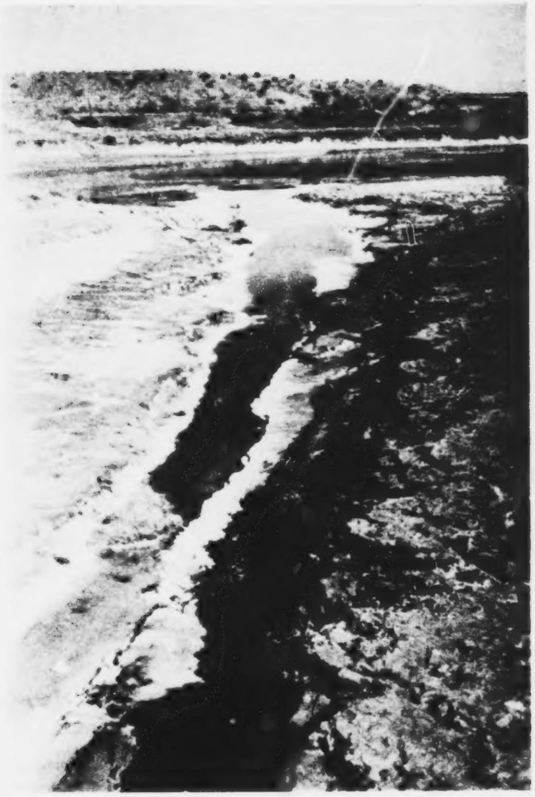


Figure 5.-Kiser Canyon looking downstream toward Elm Fork. Photograph by O.H. Linguist.

at which water was sampled in the North Fork basin. Total chloride loading from these three canyons was 378 T/D (tons per day).

Specific conductance readings on the water samples from Salton, Robinson and Kiser Canyons were 223,000, 151,000 and 227,000 micromhos per centimeter at 25°C., respectively. When comparing the ratio of chloride concentration of each water sample to the corresponding specific conductance of the sample, the respective figures are 0.86, 0.58 and 0.86. These high ratios indicate that chloride is the principal anion in the natural brine.

Fish Creek, which flows into Elm Fork about one mile downstream from Station 753, has a small spring about three miles from the confluence. At the time of sampling in March 1965, the chloride concentration was 7,600 mg/l. Total chloride loading was 1.0 T/D. The chloride/specific conductance ratio is 0.37 indicating that chloride was probably not the principal anion. Data from other sources, but not presented in this report, would indicate that sulfate is probably the principal anion in this water and occurs in a concentration exceeding 7,600 mg/l.

An unnamed tributary of Elm Fork, located six miles east and two miles north of Carl, Oklahoma, has highly saline water. This stream (designated "A" in Figure 1) had a chloride concentration of 125,000 mg/l and a specific conductance of 146,900 micromhos when sampled in March 1965. The chloride/specific conductance ratio was 0.85 indicating that chloride is the principal anion in the water. Total chloride loading was 33.8 T/D.

An unnamed tributary (designated "B" in Figure 1)is located five miles north and four and one-half miles west of Reed, Oklahoma. This tributary has salt springs about one mile above its confluence with Elm Fork. The chloride concentration of sampled water was 10,900 mg/l. Total chloride loading was 5.3 T/D. Specific conductance was 38,900 micromhos. The chloride/specific conductance ratio is 0.50. Chloride may be the principal anion in this water.

Deer Creek enters along the left bank of Elm Fork at a point about five and one-half miles north of Reed, Oklahoma. The chloride concentration of sampled water was 340 mg/l. Total chloride loading was 0.3 T/D. Specific conductance was 3,590 micromhos. The chloride/specific conductance ratio is about 0.10 indicating that chloride is probably a minor anion constituent of the water. Sulfate may be the principal anion and probably occurs in a concentration exceeding 340 mg/l.

Another unnamed tributary (designated "C" in Figure 1) is located two and one-half miles north and two and one-half miles west of Reed, Oklahoma. There are salt springs about one mile above the confluence with Elm Fork. The chloride concentration and specific conductance of sampled water were 500 mg/l and 4,210 micromhos, respectively. The chloride/specific conductance ratio is 0.12 indicating that chloride is probably a minor anion constituent of the water. Sulfate may be the principal anion and probably occurs in a concentration exceeding 500 mg/l. Total chloride loading was 0.3 T/D.

Haystack Creek, in an area about 20 miles above its confluence with Elm Fork, has a number of salt springs of small volume. During periods of low flow, very little salt water discharges to the stream. However, evaporation causes salt deposits to be formed in the upper reaches of the creek, and during periods of high flow the salt is flushed into the creek. At the time of sampling in March 1965, the chloride concentration and specific conductance were 780 mg/l and 4,320 micromhos, respectively. The chloride/specific conductance ratio was 0.18, indicating that chloride is not the principal anion in the water. Sulfate may occur in concentrations exceeding 780 mg/l. Total chloride loading was 1.0 T/D.

Salt works in the Elm Fork basin are not thought to be significant sources of salt water pollution. Originally depending on the diversion of the flow of salt water springs to the evaporation pits, present operations rely on shallow dug wells and on drilled wells. The pumping of these wells reportedly affects the flow of local springs, indicating the hydrologic continuity between the source of well brines and those issuing naturally from springs.

During the 7-year period of record, the average total daily chloride and sulfate loadings issuing from Area VI were 322 tons and 12 tons, respectively.

North Fork Basin

Two tributaries of North Fork were sampled in March 1965. These streams have the lowest chloride concentrations and are the least mineralized among those listed in Table 2. Chloride concentrations did not exceed 290 mg/l. Although sulfate was not determined, the general knowledge of the composition of waters in this region and the chloride/specific conductance ratio of the samples strongly suggest that sulfate is the principal anion in these two streams.

One tributary (designated "D" in Figure 1) is located four miles west and four and one-half miles north of Warren, Oklahoma. The chloride concentration and specific conductance of sampled water was 290 mg/l and 2,030 micromhos, respectively. Total chloride loading was about 0.3 T/D. The chloride/specific conductance ratio was 0.14, suggesting that sulfate may be the principal anion at a concentration exceeding 290 mg/l.

Elk Creek, entering North Fork from the left bank, is located four miles east and three and one-half miles north of Warren, Oklahoma. The chloride concentration and specific conductance of sampled water was 145 mg/l and 1,450 micromhos. Total chloride loading was 3.3 T/D. The chloride/specific conductance ratio is 0.10. Sulfate is assumed to be the principal anion at a concentration exceeding 145 mg/l.

During the 7-year period of record, the average total daily chloride and sulfate loadings at Sampling Station 490 were 448 tons and 314 tons, respectively. Brine discharges from Area VI accounted for approximately 72 percent of the chloride loading and 4 percent of the sulfate loading at Station 490.

STREAM QUALITY

Stream quality data used in the present study were collected at five water quality monitoring stations for various periods between July 1960 through September 1967. The start of data collection in 1960 was part of an intensive two-year investigation by the U. S. Public Health Service to locate and define natural and man-made sources of salt pollution and to determine the impact of these sources on the quality of the receiving streams. At that time two stream quality monitoring stations (Stations 754 and 753) were established on Elm Fork and one (Station 490) on North Fork. Streamflow surveillance was required and the three water quality monitoring stations were located, where possible, at existing stream gaging stations. Upon initiation of the present study in 1963, the Monitoring and Surveillance Program was continued and expanded to include two additional stations (Stations 4 and 5), which were added as a result of the Reconnaissance Survey of March 1965. The FWQA, upon receiving this project from the Public Health Service, continued the stream sampling and stream gaging programs until the end of the field studies in September 1967.

Table 3 indicates the periods when each sampling station was operative during the Monitoring and Surveillance Program. The location of these five stations are discussed in Appendix A. The important aspects of the Monitoring and Surveillance Program and the Reconnaissance Survey are discussed in Appendix B and C, respectively. The daily flow and continuous recorded quality data (specific conductance) for the period October 1960 to September 1967 is tabulated in Appendix D. Monthly summary of continuous recorded flow and quality data (specific conductance, chlorides and sulfates) are presented in Appendix E.

Elm Fork of North Fork Red River

Elm Fork is the principal source of salt water in the drainage area of the proposed Navajo Reservoir. Originating at the confluence of North Elm Creek and South Elm Creek in extreme southwestern Beckham County, Oklahoma, it flows 59 miles in an easterly direction through southwestern Oklahoma before entering the North Fork Red River. The confluence is two miles below Lake Altus and 32 miles upstream from the Navajo Reservoir damsite. The headwater streams extend into southern Wheeler County and southeastern Collingsworth County, Texas.

Table 3

DURATION OF MONITORING AND SURVEILLANCE PROGRAM

Sampling Station	Monitoring and Surveillance							
	1960	1961	1962	1963	1964	1965	1966	1967
754	*[1]	*	*					
753	*[2]	*	*	*	*	*	*	*
4						*[3]	*	*
5						*[3]	*	*
490	*[4]	*	*	*	*	*	*	*

[1] Water quality monitoring and stream gaging started in July 1960, and discontinued in September 1962.

[2] Water quality monitoring started in July 1960, and discontinued in September 1967. Stream gaging in operation from October 1959, to present.

[3] Water quality monitoring and stream gaging started in April 1965, and discontinued in September 1967.

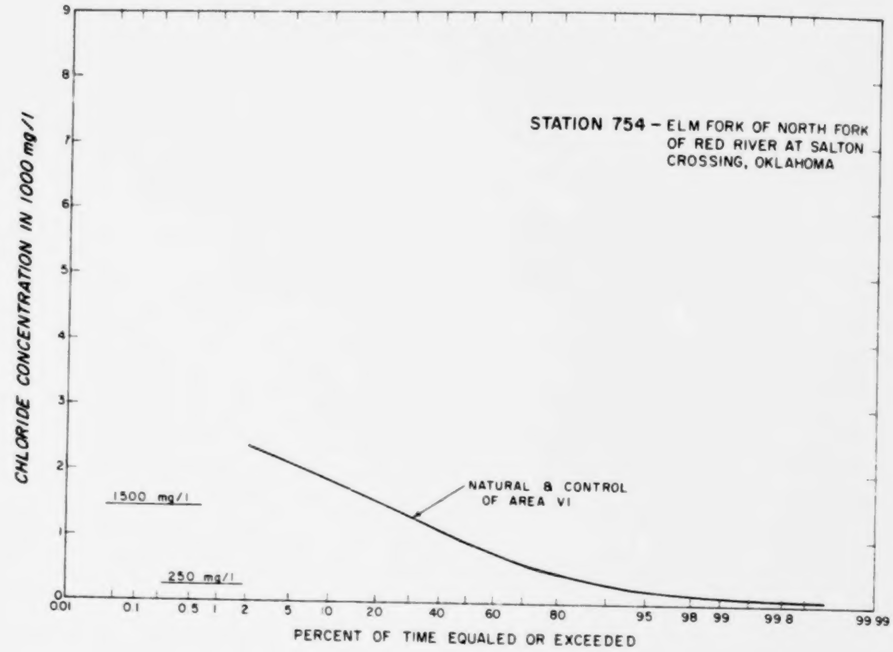
[4] Water quality monitoring started in July 1960, and discontinued in September 1967. Stream gaging in operation from April 1905, to March 1908, and from October 1937, to present.

Chloride Concentrations

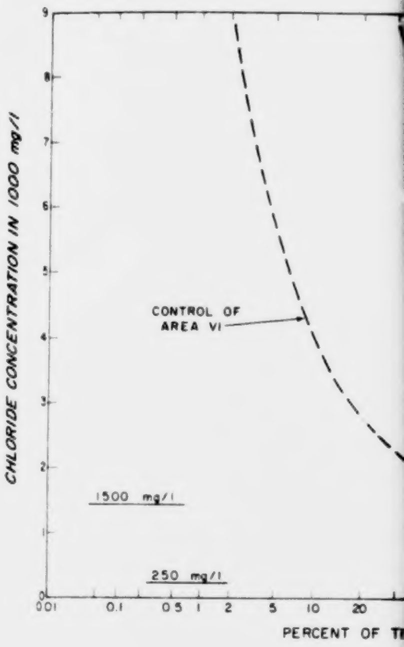
Data on the natural concentrations of chloride in Elm Fork are presented in a series of cumulative frequency diagrams in Figure 6 and a cumulative frequency data in Table 4. The flow-weighted average chloride concentrations and annual mean chloride loads for the period 1961-1967 are listed in Table 5.

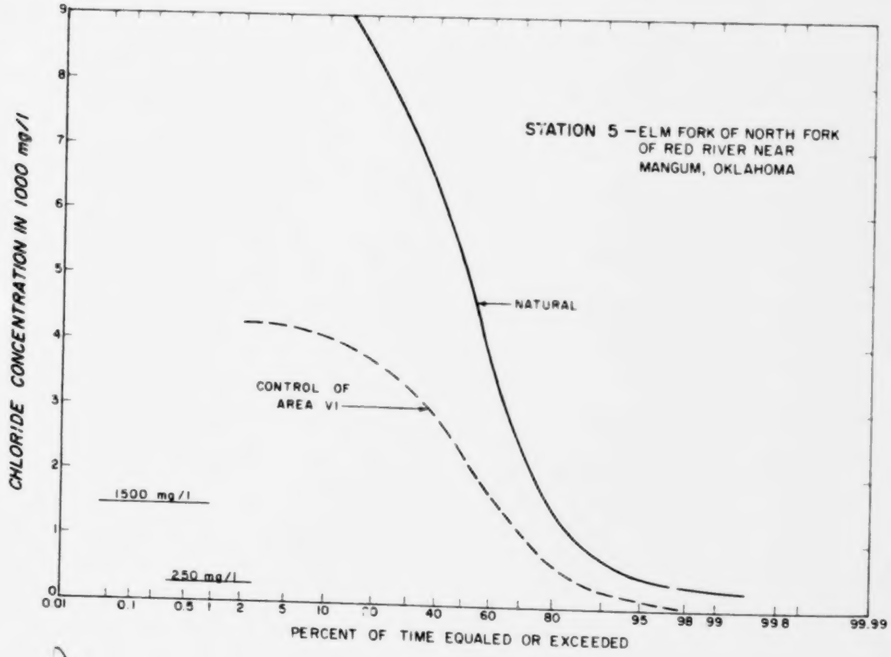
The cumulative frequency diagrams show the percent of time that certain chloride concentrations occurred at Sampling Stations 754, 753, 4 and 5. Also indicated are the extent to which extreme concentrations depart from the range of most frequent occurrence and, by comparing, how this differs from one sampling station to another. Moreover, each diagram consists of two curves, one reflecting natural conditions and the other reflecting hypothetical conditions based on the following assumptions.

1. Prevention of all brines in Area VI from draining into Elm Fork.
2. Salt mining operations in the study area remain unaltered in terms of location, salt recovery techniques, production rate or any other activity that may affect the salinization of Elm Fork.

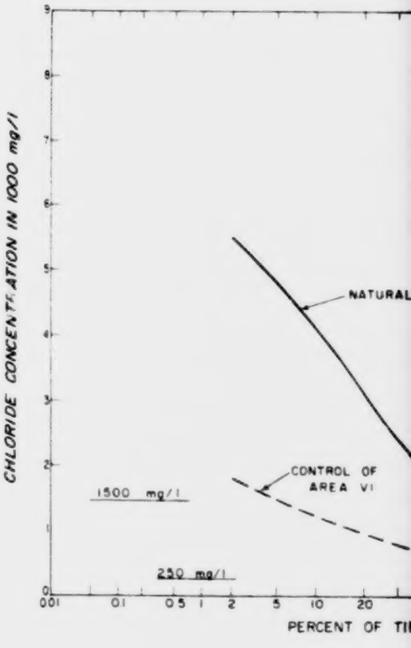


STATION 754 – ELM FORK OF NORTH FORK OF RED RIVER AT SALTON CROSSING, OKLAHOMA

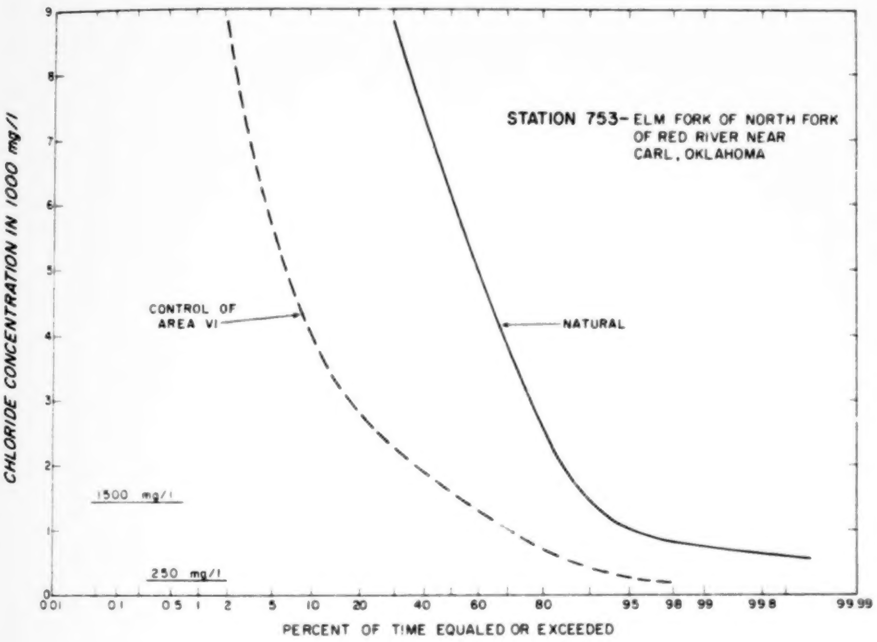


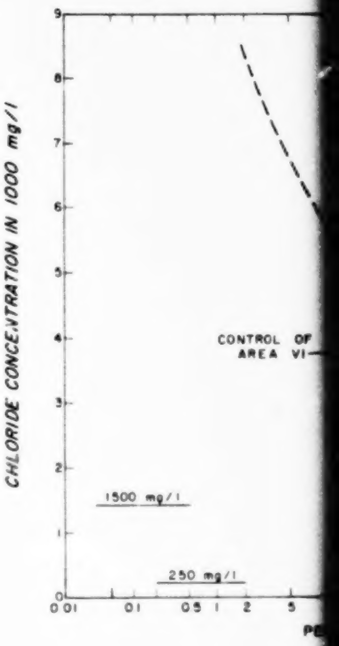


STATION 5 – ELM FORK OF NORTH FORK OF RED RIVER NEAR MANGUM, OKLAHOMA

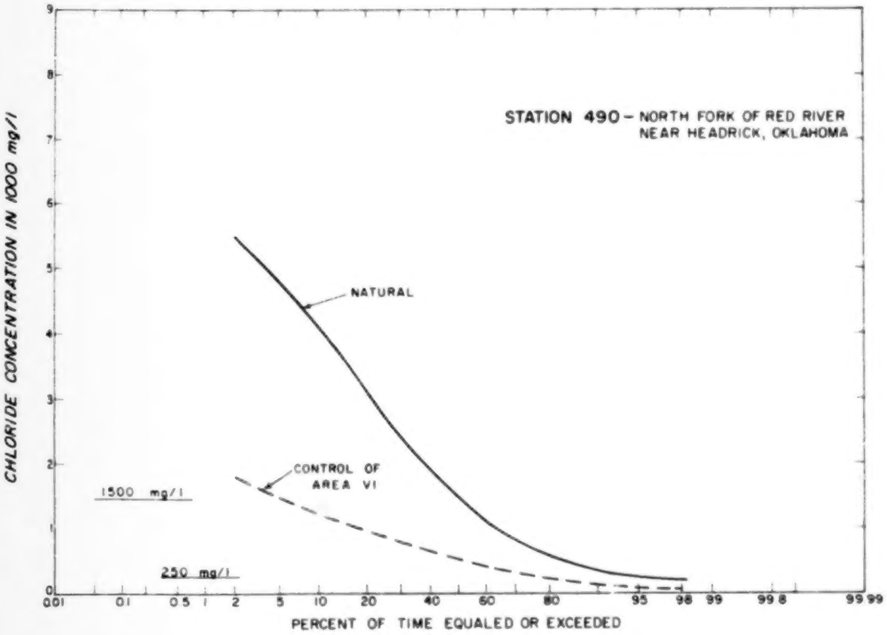


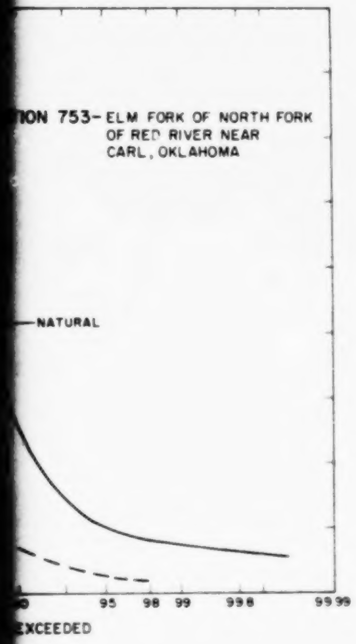
OF NORTH FORK
VER AT SALTON
, OKLAHOMA
99.8
99.99

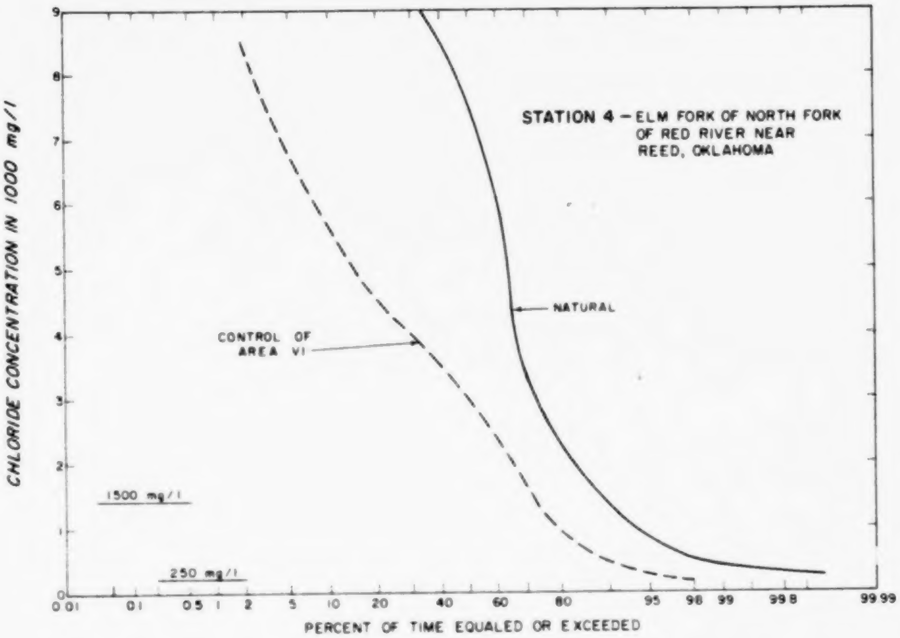

STATION 753- ELM FORK OF NORTH FORK
OF RED RIVER NEAR
CARL, OKLAHOMA
CONTROL OF
AREA VI
NATURAL
1500 mg/l
250 mg/l
CHLORIDE CONCENTRATION IN 1000 mg/l
0
1
2
3
4
5
6
7
8
9
0.01
0.1
0.5
1
2
5
10
20
40
60
80
95
98
99
99.8
99.99
PERCENT OF TIME EQUALED OR EXCEEDED

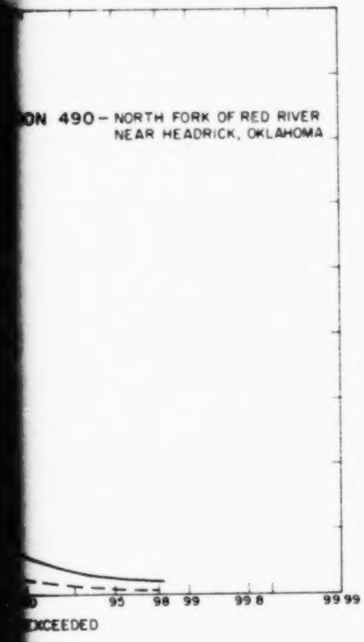

CHLORIDE CONCENTRATION IN 1000 mg/l
CONTROL OF
AREA VI
1500 mg/l
250 mg/l
0
1
2
3
4
5
6
7
8
9
0.01
0.1
0.5
1
2
5

NORTH FORK
NEAR
AHOMA
99.6
99.99


STATION 490 - NORTH FORK OF RED RIVER
NEAR HEADRICK, OKLAHOMA
NATURAL
CONTROL OF
AREA VI
1500 mg/l
250 mg/l
CHLORIDE CONCENTRATION IN 1000 mg/l
0
1
2
3
4
5
6
7
8
9
0.01
0.1
0.5
1
2
5
10
20
40
60
80
95
98
99
99.8
99.99
PERCENT OF TIME EQUALED OR EXCEEDED







ARKANSAS-RED RIVER BASINS
COMPREHENSIVE PLANNING PROJECT

CUMULATIVE FREQUENCY OF
CHLORIDE CONCENTRATIONS IN
ELM FORK AND NORTH FORK

ENVIRONMENTAL PROTECTION AGENCY
Water Quality Office
REGION VI DALLAS, TEXAS

FIGURE 6

C

Table 4

CUMULATIVE FREQUENCY DATA ON CHLORIDE CONCENTRATIONS

Percentage of Time Equaled or Exceeded	Chloride Concentrations (mg/l)[1]								
	Without Control of Area VI					With 100 Percent Control of Area VI			
	Sampling Station					Sampling Station			
	754[2]	753	4	5	490	753	4	5	490
2.0	2,180	34,670	24,490	9,500	5,480	8,860	8,400	4,300	1,740
4.0	2,150	26,610	14,450	9,200	5,040	6,800	5,950	4,200	1,600
7.0	2,000	19,070	12,142	9,150	4,650	5,070	5,570	4,100	1,460
12.0	1,770	14,500	11,700	8,970	4,120	3,750	5,340	4,050	1,300
20.0	1,540	10,410	10,200	8,400	3,160	2,650	4,290	3,800	980
30.0	1,270	8,670	9,210	7,850	2,380	2,215	3,980	3,550	740
40.0	1,100	7,780	8,120	6,400	1,930	1,990	3,690	2,900	610
50.0	880	6,580	7,610	5,190	1,320	1,670	3,160	2,350	420
60.0	825	5,470	6,480	3,800	1,020	1,400	2,700	1,720	320
70.0	770	4,150	3,000	1,790	850	990	1,880	810	270
80.0	440	2,700	2,240	1,470	780	690	920	670	250
90.0	310	1,410	1,280	720	320	360	525	325	100
97.5	290	870	445	120	245	220	180	54	80

[1] Based on monthly mean concentrations.

[2] Conditions are the same at Station 754 with or without control of Area VI.

Table 5

MEAN ANNUAL STREAMFLOWS, CHLORIDE CONCENTRATIONS AND CHLORIDE LOADINGS, 1961-1967

Location	Water Year						
	1961	1962	1963	1964	1965	1966	1967
Station 754[1]							
Flow (cfs)	51	57	25	26	45	42	46
Chloride Conc. (mg/l)	669	520	1,060	1,130	1,110	1,448	1,200
Chloride Loading (T/D)	92	80	72	79	136	164	149
Station 753							
Flow	51	57	25	26	45	42	46
Chloride Conc.	2,590	2,050	4,130	4,480	4,353	5,700	4,720
Chloride Loading	358	315	281	310	533	645	584
Station 4[2]							
Flow	76	85	31	33	102	59	61
Chloride Conc.	3,120	2,710	5,380	4,500	1,898	3,200	3,220
Chloride Loading	640	623	450	400	553	510	533
Station 5[2]							
Flow	145	157	58	55	197	92	81
Chloride Conc.	1,460	1,390	2,790	2,880	911	1,730	2,180
Chloride Loading	670	690	510	500	484	427	478
Station 490							
Flow	589	427	140	69	241	203	113
Chloride Conc.	466	499	846	1,190	485	1,020	1,350
Chloride Loading	741	570	319	221	315	558	411

[1] Data for 1963 - 1967 are estimated.

[2] Data for 1961 - 1964 are estimated.

3. General climatic conditions affecting the study area remain unchanged.
4. No man-made structures alter the natural flow of the stream except in Area VI.
5. No additional man-made pollution of Elm Fork.

Table 4 lists cumulative frequency data on chloride concentrations for conditions as they existed during the study and for hypothetical controlled conditions in which the quality of Elm Fork is assumed unaffected by natural brines from Area VI.

Table 5 lists the mean annual streamflow, chloride concentrations and chloride loading of Elm Fork for the period 1961-1967.

Of the four sampling stations established on Elm Fork, the highest chloride concentrations occur at Station 753, located immediately downstream from Area VI. At Station 753 chloride concentrations equal or exceed 1,410 mg/l 90 percent of the time and 6,580 mg/l 50 percent of the time. At Station 754, which is immediately upstream from Area VI, chloride concentrations equal or exceed 310 and 880 mg/l 90 and 50 percent of the time, respectively. Station 5 is farthest downstream on Elm Fork (36.2 miles below Station 753). The chloride concentrations at this station equal or exceed 720 mg/l and 5,190 mg/l 90 and 50 percent of the time, respectively. Of the four stations established on Elm Fork, water quality data collected at Station 754 and

753 define the impact that the natural brines from Area VI have on Elm Fork. Station 5 is closest to the proposed Navajo Reservoir and water quality data collected at this location represents the net effect of all upstream factors contributing to the chloride content of Elm Fork. For these reasons the water quality at this station is particularly important in estimating the water quality of the proposed impoundment.

The flow-weighted average chloride concentration and annual mean chloride load, as indicated in Table 5, range respectively from a maximum of 5,700 mg/l and 645 T/D at Sampling Station 753 to a minimum of 520 mg/l and 72 T/D at Sampling Station 754 for seven years of record. At Sampling Station 5 the annual mean chloride concentration and chloride load range, respectively, from a maximum of 2,180 mg/l and 484 T/D to a minimum of 911 mg/l and 427 T/D for three years of records.

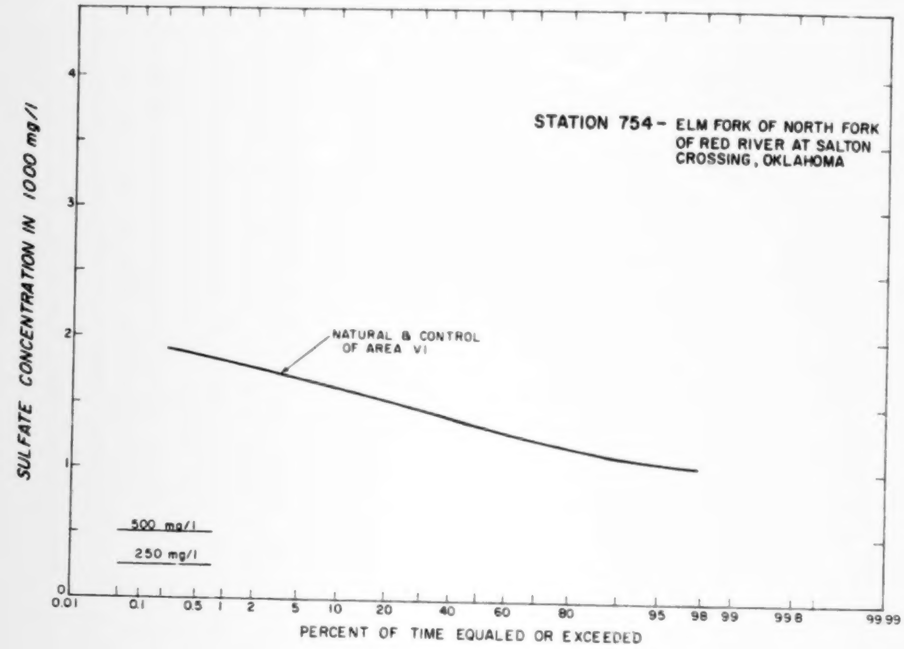
Control of Area VI, which is the hypothetical condition of pollution abatement previously discussed, would result in a large reduction in chloride concentrations. At Sampling Station 753 and 5, the controlled chloride concentrations that would occur are 525 and 100 mg/l or more 90 percent of the time, which indicate decreases of 885 and 220 mg/l or more 90 percent of the time from the natural chloride concentrations at these respective stations. The controlled chloride concentrations at Stations 753 and 5 are 1,670 and 420 mg/l or more 50 percent of the time. The corresponding decreases from the natural chloride concentrations are 4,910 and 2,840 mg/l or more 50 percent of the time.

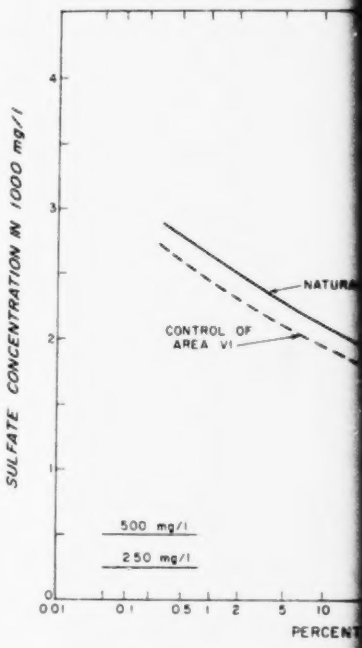
Sulfate Concentrations

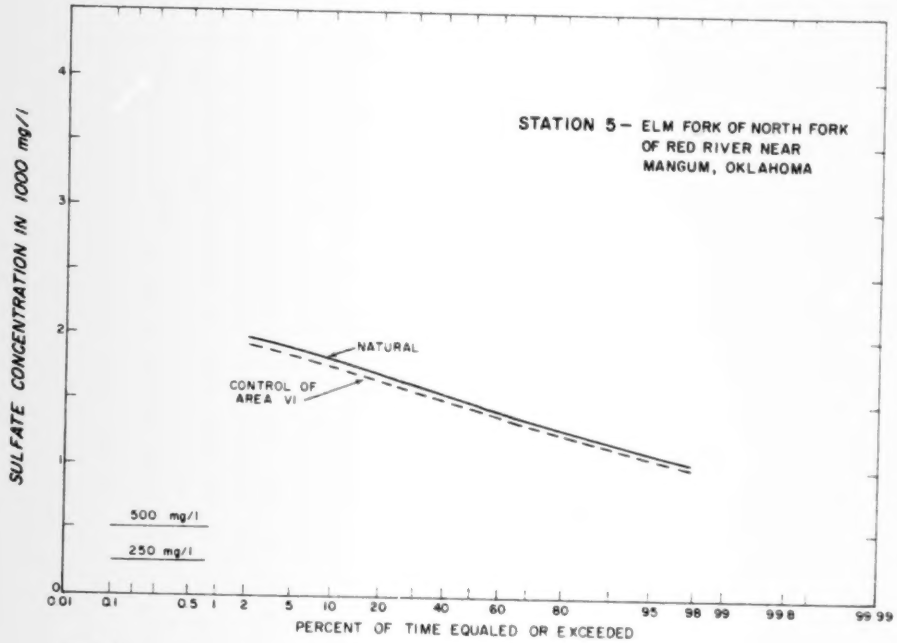
Data on the natural concentrations of sulfate in Elm Fork are presented in a series of cumulative frequency diagrams in Figure 7 and as cumulative frequency data in Table 6. The annual mean sulfate concentrations and sulfate loads for the period 1961-1967 are listed in Table 7.

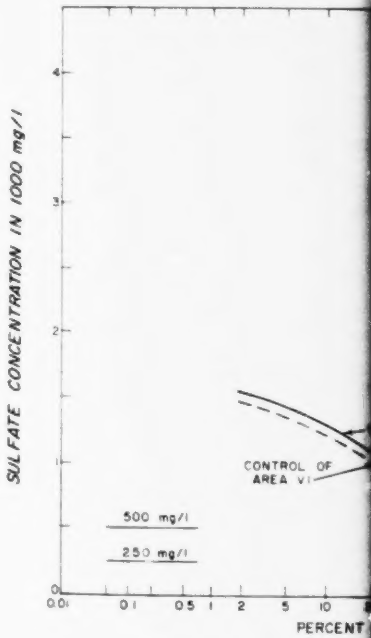
Under the previous discussions of chloride concentrations in Elm Fork, reference was made to cumulative frequency diagrams. Statements regarding the significance of these diagrams and of the cumulative frequency curves apply also to the present discussion of sulfate.

Of the four sampling stations established on Elm Fork, the highest sulfate concentrations occur at Station 753 and equal or exceed 1,240 mg/l 90 percent of the time and 1,630 mg/l 50 percent of the time. At Station 754, sulfate concentrations equal or exceed 1,050 and 1,370 mg/l 90 and 50 percent of the time, respectively. Sulfate concentrations at Station 5 equal or exceed 1,070 and 1,680 mg/l 90 and 50 percent of the time, respectively.

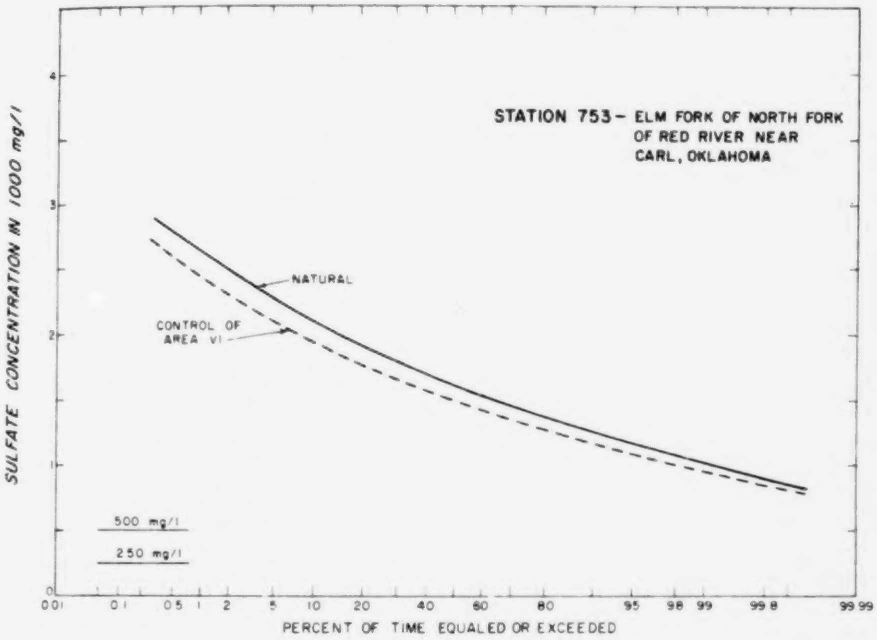

STATION 754 - ELM FORK OF NORTH FORK OF RED RIVER AT SALTON CROSSING, OKLAHOMA
NATURAL & CONTROL OF AREA VI
SULFATE CONCENTRATION IN 1000 mg/l
PERCENT OF TIME EQUALED OR EXCEEDED
500 mg/l
250 mg/l
0
1
2
3
4
0.01
0.1
0.5
1
2
5
10
20
40
60
80
95
98
99
99.8
99.99

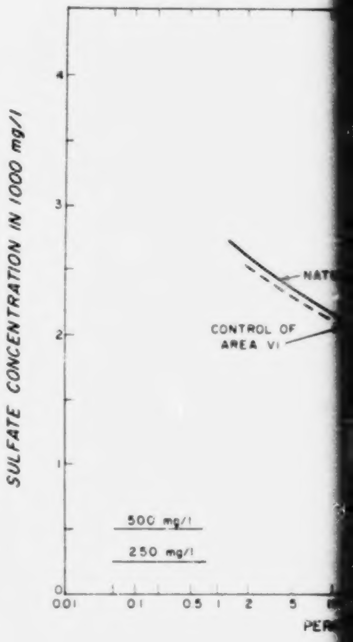

NATURA
CONTROL OF AREA VI
SULFATE CONCENTRATION IN 1000 mg/l
PERCENT
500 mg/l
250 mg/l
0
1
2
3
4
0.01
0.1
0.5
1
2
5
10

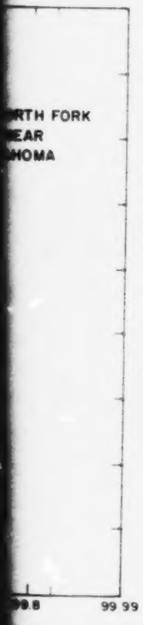

STATION 5 - ELM FORK OF NORTH FORK OF RED RIVER NEAR MANGUM, OKLAHOMA
NATURAL
CONTROL OF AREA VI
SULFATE CONCENTRATION IN 1000 mg/l
PERCENT OF TIME EQUALED OR EXCEEDED
500 mg/l
250 mg/l
0
1
2
3
4
0.01
0.1
0.5
1
2
5
10
20
40
60
80
95
98
99
99.8
99.99

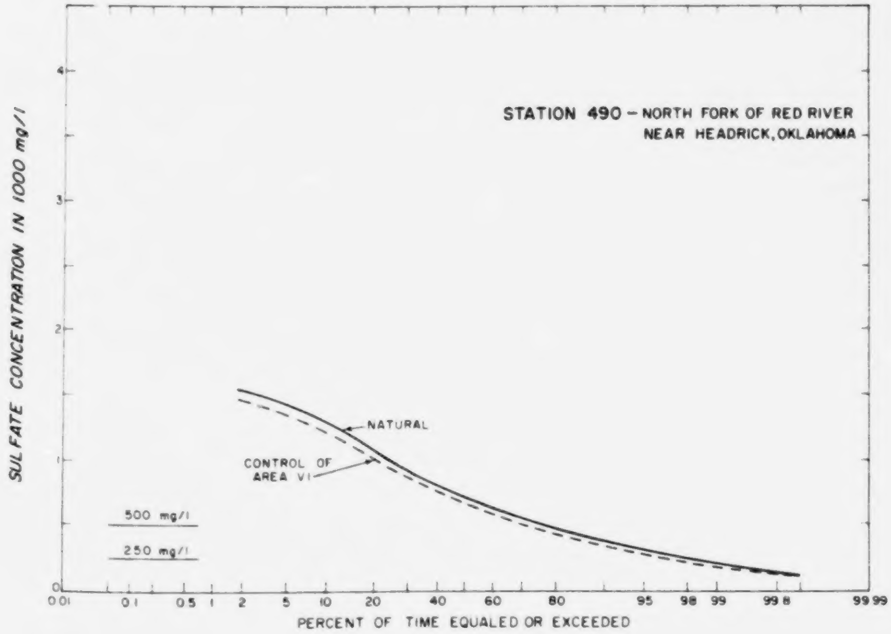

CONTROL OF AREA VI
SULFATE CONCENTRATION IN 1000 mg/l
PERCENT
500 mg/l
250 mg/l
0
1
2
3
4
0.01
0.1
0.5
1
2
5
10

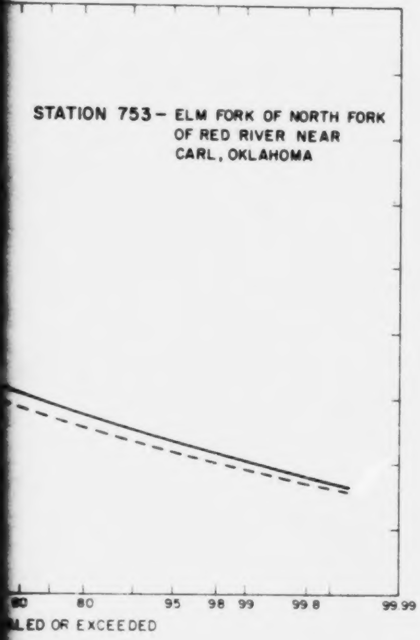
OF NORTH FORK
VER AT SALTON
, OKLAHOMA
99.8
99.99

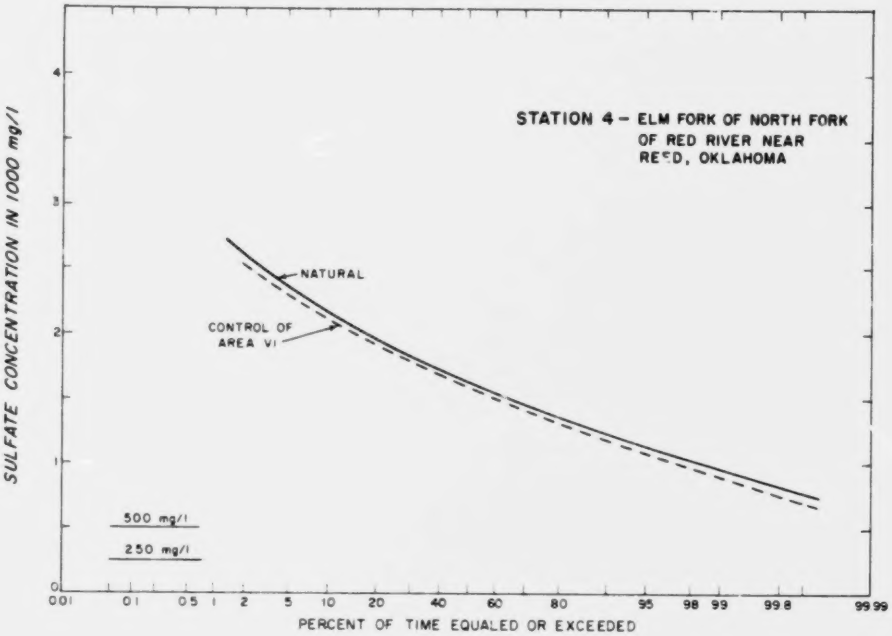

STATION 753 – ELM FORK OF NORTH FORK
OF RED RIVER NEAR
CARL, OKLAHOMA
SULFATE CONCENTRATION IN 1000 mg/l
4
3
2
1
0
NATURAL
CONTROL OF
AREA VI
500 mg/l
250 mg/l
0.01
0.1
0.5
1
2
5
10
20
40
60
80
95
98
99
99.8
99.99
PERCENT OF TIME EQUALED OR EXCEEDED

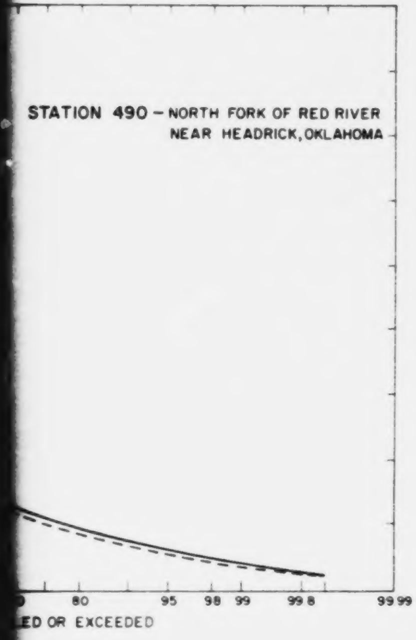

SULFATE CONCENTRATION IN 1000 mg/l
4
3
2
1
0
NATU
CONTROL OF
AREA VI
500 mg/l
250 mg/l
0.01
0.1
0.5
1
2
5
PER


RTH FORK
EAR
HOMA
99.8
99.99


STATION 490 – NORTH FORK OF RED RIVER
NEAR HEADRICK, OKLAHOMA
SULFATE CONCENTRATION IN 1000 mg/l
4
3
2
1
0
NATURAL
CONTROL OF
AREA VI
500 mg/l
250 mg/l
0.01
0.1
0.5
1
2
5
10
20
40
60
80
95
98
99
99.8
99.99
PERCENT OF TIME EQUALED OR EXCEEDED







ARKANSAS–RED RIVER BASINS
COMPREHENSIVE PLANNING PROJECT

CUMULATIVE FREQUENCY OF
SULFATE CONCENTRATIONS IN
ELM FORK AND NORTH FORK

ENVIRONMENTAL PROTECTION AGENCY
Water Quality Office
REGION VI
DALLAS, TEXAS

FIGURE 7

Table 6

CUMULATIVE FREQUENCY DATA ON SULFATE CONCENTRATIONS

Percentage of Time Equaled or Exceeded	Sulfate Concentrations (mg/1)[1/]								
	Without Control of Area VI					With 100 Percent Control of Area VI			
	Sampling Station					Sampling Station			
	754[2/]	753	4	5	490	753	4	5	490
2.0	1,730	2,490	2,590	1,970	1,510	2,305	2,480	1,915	1,460
4.0	1,720	2,180	2,580	1,830	1,370	2,020	2,470	1,790	1,320
7.0	1,700	2,090	2,420	1,760	1,220	1,930	2,300	1,700	1,170
12.0	1,640	1,970	2,130	1,740	1,150	1,830	2,040	1,690	1,120
20.0	1,580	1,870	1,910	1,725	1,070	1,730	1,820	1,670	1,030
30.0	1,520	1,740	1,810	1,710	1,000	1,615	1,730	1,660	970
40.0	1,450	1,670	1,780	1,700	910	1,545	1,700	1,650	910
50.0	1,370	1,630	1,750	1,680	830	1,510	1,680	1,630	810
60.0	1,350	1,590	1,690	1,670	655	1,470	1,620	1,620	630
70.0	1,330	1,515	1,480	1,540	530	1,400	1,420	1,500	510
80.0	1,150	1,420	1,340	1,180	475	1,315	1,280	1,150	460
90.0	1,050	1,240	1,220	1,070	330	1,140	1,170	1,040	320
97.5	1,040	1,080	1,030	1,050	200	1,000	990	1,020	190

[1/] Based on monthly mean concentrations.

[2/] Conditions are the same at Station 754 with or without control of Area VI.

Table 7

MEAN ANNUAL STREAMFLOWS, SULFATE CONCENTRATIONS AND SULFATE LOADINGS, 1961 - 1967

Location	Water Year						
	1961	1962	1963	1964	1965	1966	1967
Station 754[1]							
Flow (cfs)	51	57	25	26	45	42	46
Sulfate Conc. (mg/l)	1,282	1,203	1,410	1,400	1,460	1,470	1,260
Sulfate Loading (T/D)	177	185	96	98	179	166	156
Station 753							
Flow	51	57	25	26	45	42	46
Sulfate Conc.	1,380	1,310	1,530	1,530	1,582	1,580	1,370
Sulfate Loading	190	201	104	106	194	179	169
Station 4[2]							
Flow	76	85	31	33	102	59	61
Sulfate Conc.	1,416	1,360	1,735	1,570	1,489	1,458	1,330
Sulfate Loading	290	312	145	140	433	232	220
Station 5[2]							
Flow	145	157	58	55	197	92	81
Sulfate Conc.	1,400	1,390	1,420	1,410	1,130	1,681	1,240
Sulfate Loading	640	690	260	245	601	415	272
Station 490							
Flow	589	427	140	69	241	203	113
Sulfate Conc.	300	317	656	596	506	682	972
Sulfate Loading	477	362	247	111	329	373	296

[1] Data for 1963 - 1967 are estimated.
[2] Data for 1961 - 1964 are estimated.

The flow-weighted average sulfate concentrations and mean annual sulfate loads, as indicated in Table 7, range from the maximums of 1,681 mg.1 and 601 T/D at Station 5 to the minimums of 1,130 mg/1 and 96 T/D at Stations 5 and 754, respectively. At Station 5 the mean annual sulfate concentration and load range from the maximums of 1,681 mg/1 and 601 T/D to the minimums of 1,130 mg/1 and 272 T/D for the three years of record.

Control of Area VI would result in a small reduction in sulfate concentrations. At Sampling Stations 753 and 5, the controlled sulfate concentrations that would occur are 1,140 and 1,040 mg/1 or more 90 percent of the time, respectively, which amount to decreases of 100 and 30 mg/1 or more 90 percent of the time from the natural sulfate concentrations at these respective stations. The controlled sulfate concentrations at Stations 753 and 5 are 1,510 and 1,630 mg/1 or more 50 percent of the time. The corresponding decreases from the natural chloride concentrations are 120 and 50 mg/1 or more 50 percent of the time.

North Fork Red River

North Fork is the primary source of water for impoundment in the proposed Navajo Reservoir. Originating in Gray County, near Pampa, Texas, it flows easterly and southerly through the Texas panhandle country and southwestern Oklahoma before entering the Red River. Elm Fork enters North Fork at a point 70.9 miles upstream from where North Fork joins the Red River.

Chloride Concentrations

Data on the natural concentrations of chloride at Sampling Station 490 on the North Fork are included as a cumulative frequency diagram in Figure 6 and as cumulative frequency data in Table 4. The flow-weighted average chloride concentrations and annual mean chloride loads for the period 1961-1967 are listed in Table 5.

Sampling Station 490 is located 10.4 miles downstream from the damsite of the proposed Navajo Reservoir. Of the five stations established as part of the Monitoring and Surveillance Program, the water quality at Sampling Station 490 is thought to represent most closely the quality of the North Fork as it would flow into the proposed reservoir.

Elm Fork enters North Fork 32 miles upstream from the damsite and 9 miles upstream from where the blended waters of the two streams would enter the reservoir.

At Sampling Station 490 the chloride concentrations that occur are 320 mg/l or more 90 percent of the time. The chloride concentrations are 1,320 mg/l or more 50 percent of the time.

The flow-weighted average chloride concentration and annual mean chloride load, as indicated in Table 5, range, respectively, from a maximum of 1,350 mg/l and 741 T/D to a minimum of 466 mg/l and 221 T/D for the seven years of record.

Control of Area VI would result in a large reduction of chloride concentrations at Sampling Station 490. Concentrations that occur are 100 and 420 mg/l or more 90 percent and 50 percent of the time, respectively, which indicates decreases of 220 and 900 mg/l or more from the corresponding natural chloride concentrations.

Sulfate Concentrations

Data on the natural concentrations of sulfate at Sampling Station 490 on North Fork are included as a cumulative frequency diagram in Figure 7 and as cumulative frequency data in Table 6. The annual mean sulfate concentrations and sulfate loads for the period 1961-1967 are listed in Table 7.

At Sampling Station 490 the sulfate concentrations that occur are 330 mg/1 or more 90 percent of the time. The sulfate concentration is 830 mg/1 or more 50 percent of the time.

The flow-weighted average sulfate concentration and annual mean sulfate load, as indicated in Table 7, range, respectively, from a maximum of 972 mg/1 and 477 T/D to a minimum of 300 mg/1 and 111 T/D for the seven years of record.

Control of Area VI would result in small reduction of sulfate concentrations at Sampling Station 490. Concentrations that occur 90 percent and 50 percent of the time are 320 and 810 mg/1 or more, respectively, which indicate decreases of 10 and 20 mg/1 or more from the corresponding natural sulfate concentrations.

NAVAJO RESERVOIR

The critical consideration regarding the proposed Navajo Reservoir is the suitability of the impounded water for municipal, industrial and agricultural supply. Plans for the reservoir have remained tentative and the project did not reach the state of final engineering design when it was inactivated. Details on the design characteristics of the reservoir are, therefore, also tentative.

The damsite traverses the North Fork Red River approximately two miles east and five miles north of the village of Headrick in Sec. 33, T.3 N., R. 18 W., at a point 43.4 miles upstream from where the North Fork flows into the Red River. Dam freeboard is 1,436 feet above mean sea level (ft.-m.s.l.) with a maximum water surface elevation of 1,430 ft.-m.s.l. Corresponding maximum water surface area and total reservoir capacity are 20,526 acres and 546,972 acre-feet, respectively. Elevations of proposed conservation pools are 1,400, 1,410, and 1,418 ft.-m.s.l. Corresponding water surface area and conservation storage at 1,400 ft.-m.s.l. is 7,823 acres and 144,648 acre-feet, respectively. Streambed elevation at the damsite is 1,346 ft.-m.s.l. At full capacity, the reservoir will inundate the valley of the North Fork to a point approximately 23 river miles upstream from the dam. The valley of Elk Creek will be inundated approximately 5 river miles upstream from where it joins the North Fork in Sec. 12, T.4N., R.19E.

Water Uses and Water Quality Criteria

The water impounded by the proposed Navajo Reservoir is intended to serve as a source of municipal and industrial water supply. The FWQA, in evaluating the suitability of this water for these two uses extended this evaluation to include agricultural water use for livestock watering and irrigation.

In the present study, water quality conditions relating to the Navajo Reservoir are discussed in terms of concentrations of chloride and sulfate and in terms of specific conductance. To evaluate the water suitability for irrigation, the sodium-adsorption ratio was calculated. Criteria presented in Table 8 are selected from *Water Quality Criteria*, a report of the National Technical Advisory Committee to the Secretary of the Interior, and from *Water Quality Criteria*, a report by the California Water Quality Control Board.

Table 8

SELECTED WATER QUALITY CRITERIA FOR MUNICIPAL, INDUSTRIAL, AND AGRICULTURAL WATER USES

Water Use	Water Quality Criteria		
	Chloride (mg/1)	Sulfate (mg/1)	Specific Conductance (micromhos/cm)
Municipal	250[1]	250[1]	--[2]
Industrial	200-22,000[3]	570-2,700[3]	--[2]
Agricultural			
Livestock Watering	1,500[4]	1,000[4]	--[2]
Irrigation	--[2]	--[2]	1,000-12,800[5]

[1] Applies to raw surface water after treatment that may include coagulation, sedimentation, filtration and disinfection.

[2] Not a water quality parameter for the water use indicated. Excess concentrations of another parameter will ordinarily deter water use first.

[3] Applies to raw surface water to be used for diverse industrial purpose that include boiler makeup, cooling, and process water for textile, lumber, pulp and paper, chemical, petroleum, primary metals, food and kindred products, and leather industry.

[4] Suggested or assumed maximum level of concentration.

[5] Criteria applicable to large variety of crops that collectively span a wide range in salt tolerance.

Water quality criteria form the basis for evaluating water suitability for the designated uses. These criteria are founded on empirical data and precautionary judgment arrived at to protect public health, safeguard industrial processes and equipment and promote agricultural productivity.

The listed criteria are presented in relation to municipal, industrial and agricultural water supplies. Agricultural water use is divided into two categories: stock watering and irrigation.

Water Quality of the Navajo Reservoir

The water quality of the Navajo Reservoir is determined by a number of factors. Principal among these are the quantity and quality of water in storage in the reservoir at the outset of reservoir operations; the quantity and quality of inflow under alternative levels of quality control of Area VI; the quantity of evaporation loss from the reservoir; and the controlled reservoir withdrawals for the proposed water uses.

The quantity of water in the reservoir at the outset was assumed to be 144,648 acre-feet, the capacity of the reservoir corresponding to the 1,400-foot conservation pool elevation. The quality of water was based on the flow-weighted mean chloride and sulfate concentrations (655 and 455 mg/l, respectively) at Sampling Station 490.

To estimate the chloride and sulfate concentrations at Station 490, under alternative conditions of water-quality control of Area VI, the average salt loadings from Area VI were determined for the 7-year period of record. The chloride and sulfate loadings from Area VI constituted 72 percent of the chloride loading and 4 percent of the sulfate loading at Station 490. Under the assumed levels of zero percent, 80 percent and 100 percent control of salt loadings from Area VI, the resulting conditions at Station 490 were calculated by correspondingly reducing the loading from Area VI at that station.

The weighted average chloride and sulfate concentrations of the North Fork at Station 490 under no control, 80 percent control and 100 percent control of brine discharges from Area VI are presented in Table 9.

Inflow characteristics were the mean monthly streamflow and water quality of the North Fork at Sampling Station 490 for the seven year period of record spanning water years 1961-1967. This station is located 42 river

Table 9

WATER QUALITY OF NORTH FORK RED RIVER
AT SAMPLING STATION 490

Control of Area VI of Elm Fork	Flow-Weighted Average Chloride and Sulfate Concentrations at Sampling Station 490 (mg/l)[1]
Chloride Concentrations:	
No control of Area VI	655
80 percent control	275
100 percent control	185
Sulfate Concentrations:	
No control of Area VI	455
80 percent control	445
100 percent control	440

[1] All concentrations rounded to nearest five milligrams per liter.

miles downstream from where Elm Fork joins North Fork and 10 river miles below the proposed dam. Water quality at this location should closely represent the complete blend of waters flowing into the reservoir from North Fork.

Evaporation losses are based on mean monthly reservoir evaporation rates obtained from the Texas Water Development Board for Quadrangle C-8, which includes the area of the proposed Navajo Reservoir in southwestern Oklahoma. The increasing mineralization of the impounded water due to evaporation was calculated into the estimations of reservoir quality for an extrapolated period covering 50 years of hypothetical reservoir operation. The controlled yields from the reservoir were 6,666 acre-feet per month.

In estimating the water quality of the Navajo Reservoir, the cumulative average chloride and sulfate concentrations were determined by reservoir routing analysis and calculated for 5, 10, 20, 30, 40 and 50 years of reservoir operation. The chloride and sulfate reservoir routing analysis establishes a hydrologic system in which those factors that determine reservoir quality are brought together in mathematical formula used to calculate mean monthly chloride and sulfate concentrations.

Starting with a given quantity and quality of water in the proposed reservoir, the inflow from North Fork is assumed to be completely mixed with the water in the reservoir. The combined volume of the impounded waters is then subject to evaporation at the appropriate monthly rate. The increased mineralization due to evaporation is assumed to be uniformly dispersed throughout the impoundment, giving the quality of the reservoir for the particular month involved. A new initial reservoir capacity is calculated for the end of month conditions. This is determined by taking the reservoir capacity for the previous month, adding inflow, and subtracting the evaporation loss and controlled reservoir yield.

To obtain information on the changing quality of the reservoir over the years, caused in part by increasing mineralization due to evaporation, water quality estimates were extrapolated over a 50 year period by uniform random recycling, on a year by year basis, of the monthly mean streamflows, chloride and sulfate concentrations and evaporation rates for the seven years of field records. Three sets of recycled data, each covering a random 50 year sequence, were computed and averaged to obtain yearly mean chloride and sulfate concentrations. Table 10 presents the estimated cumulative mean chloride and sulfate concentrations in the Navajo Reservoir for 50 years of operation without control and with 80 percent control and 100 percent control of Area VI. The concentrations are rounded to the closest 5 milligrams per liter.

As part of the calculations in estimating the chloride and sulfate concentrations, reservoir routing analyses were made assuming the reservoir was initially filled to three alternative conservation pool levels (1,400, 1,410 and 1,418 ft.-m.s.l.) with water having mean chloride and sulfate concentrations of 653 and 457 mg/l, respectively. In each of these three reservoir routings, the initital differences in the quantities of water in storage (144,648 acre-feet at the 1,400 foot level, 238,577 acre-feet at 1,410 foot, and 339,473 acre-feet at the 1,418 foot level) caused a difference of less than 5 mg/l in chloride and sulfate concentrations after the first year of reservoir operation.

The projected quality estimates are based on existing conditions at the time of the field investigations. Future upstream developments may affect these estimates.

Table 10

ESTIMATED WATER QUALITY OF THE NAVAJO RESERVOIR DURING 50 YEARS OF OPERATION

Control of Area VI of Elm Fork	Cumulative Average Chloride and Sulfate Concentrations (mg/l) Versus Years of Reservoir Operation					
	Years of Reservoir Operation					
	5	10	20	30	40	50
Chloride Concentrations						
No control of Area VI	1,015	1,070	1,145	1,270	1,140	1.265
80 percent control	430	455	485	540	485	540
100 percent control	285	300	320	355	320	355
Sulfate Concentrations						
No control of Area VI	655	705	745	740	770	760
80 percnet control	645	685	720	715	745	735
100 percent control	640	680	715	710	740	730

Chloride Concentrations

As indicated in Table 9, the estimated mean chloride concentration of the North Fork is 655 mg/l at Sampling Station 490. Assuming 80 and 100 percent control of the concentration of salt brines issuing from Area VI on Elm Fork, the flow-weighted average chloride concentrations would be reduced to 275 and 185 mg/l, respectively.

The estimated cumulative average chloride concentration of the Navajo Reservoir over 50 years of hypothetical reservoir operations, under assumed alternative conditions of no control and of 80 and 100 percent control of the concentrations of Area VI, range from 285 to 1,270 mg/l, as indicated in Table 10.

Without quality control of Area VI the estimated cumulative average chloride concentrations in the Navajo Reservoir range from 1,015 mg/l to 1,270 mg/l over the 50 years of reservoir operation. The maximum monthly average to occur in the reservoir during this same period was 2,410 mg/l.

With 80 percent control of Area VI, the cumulative average chloride concentrations range from 430 mg/l to 540 mg/l over the 50 year period.

Assuming 100 percent control of Area VI, the estimated cumulative averages range from 285 mg/l to 355 mg/l over the 50 years of operation.

Sulfate Concentrations

As indicated in Table 9, the estimated mean sulfate concentration of the North Fork is 455 mg/l at Sampling Station 490. Assuming 80 and 100 percent effective control of the concentration of salt brines issuing from Area VI on Elm Fork, the flow-weighted average sulfate concentrations at Station 490 would be reduced to 445 and 440 mg/l, respectively.

The estimated cumulative average sulfate concentration of the Navajo Reservoir after 5 to 50 years of reservoir operation, under assumed alternative conditions of no control and of 80 and 100 percent control of Area VI, range in accumulative averages from 640 to 760 mg/l.

Without quality control of Area VI, the estimated cumulative average sulfate concentrations in the Navajo Reservoir range from 655 mg/l to 760 mg/l over the 50 years of hypothetical reservoir operation. The maximum monthly average to occur during this same period was 1,395 mg/l.

With 80 percent control of Area VI, the cumulative average sulfate concentrations range from 645 mg/l to 735 mg/l over the 50 year period.

Assuming 100 percent control of Area VI, the estimated accumulative averages range from 640 mg/l to 730 mg/l over the 50 years of operation.

Water Suitability

Municipal Supply

Evaluating the suitability of water for municipal supply is complicated by the fact that raw surface water supplies are commonly treated for quality improvement before distribution to the water customers. Generally undesirable water supplies such as ocean water or grossly polluted fresh water can, at a price, be converted to potable and palatable water. However, when considering only the more common treatment practices, such as coagulation, sedimentation, filtration and disinfection, the chloride and sulfate concentrations of the raw supply are unaffected by such treatment. The present evaluation of water suitability assumes only the four common types of pre-treatment referred to above; and that the chloride and sulfate concentrations of the raw reservoir water would prevail undiminished in the water delivered from the reservoir to the user.

Quality criteria established for public drinking water specifies permissible maximums of 250 mg/l for both chloride and sulfate concentrations. Thus the cumulative average concentrations of chloride and sulfate, under the several conditions of quality control of Area VI, exceed the permissible maximums by 105 to

1,020 mg/l for chloride and by 480 to 510 mg/l for sulfate. Thus, the quality of the Navajo Reservoir is unsuitable for public water supply.

Industrial Supply

Industrial water quality requirements are almost as varied and numerous as there are types of industrial products. For this reason no criteria relating to the chloride or sulfate concentrations of raw surface water supplies can apply to a large number of industrial water uses. Moreover, pre-treatment techniques permit utilizing water of grossly substandard quality to produce water of acceptable quality at the point of use. The present appraisal of water suitability is based on quality characteristics of surface waters that have been used as sources of industrial water supply.

The maximum concentrations of chloride in waters that have been used as sources of industrial supply range from 200 mg/l in process water of the pulp and paper industry to 22,000 mg/l in brackish cooling water in once-through systems and in the makeup cycle.

Chloride concentrations in the Navajo Reservoir are estimated to range from a cumulative average of 1,015 to 1,270 mg/l over the 50 years of hypothetical reservoir operation, assuming no control of Area VI. Compared with the maximums established by industry, this range of concentration is within the quality limits for process water used in the petroleum industry (1,600 mg/1 maximum), for boiler makeup water (19,000 mg/1), and for those industries where brackish water is used as cooling water in once-through systems and in the makeup recyle (22,000 mg/1). The estimated chloride concentrations exceed the maximums for process water in the pulp and paper industry (200 mg/1 1/), chemical industry (500 mg/1), and prime metals industry (500 mg/1), and for fresh cooling water in a once-through system (600 mg/1) and in the makeup recycle (500 mg/1).

With 80 percent control of Area VI, the estimated chloride concentrations range from a cumulative average of 430 to 540 mg/1 over the 50 years of reservoir operation. These concentrations are within the quality limits of the same industries discussed above under conditions of no control of Area VI. The estimated chloride concentrations exceed the maximum for process water in the pulp and paper industry (200 mg/1 1/). For process water used in primary metals industries, and for fresh cooling water in the

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1/ May be 1,000 mg/1 or less for mechanical pulping operations.

once-through system and in the makeup recycle, the reservoir is of marginal quality with respect to accumulative average chloride concentrations with 80 percent control of Area VI. However, the cumulative averages do not reflect the large fluctuations in quality that frequently exceed the criteria for these water uses. Although periods of satisfactory reservoir quality do occur, these periods are temporary. The reliability of the reservoir quality is low. Standard deviations, based upon the yearly average concentrations for the three sets of 50-year projected reservoir use, are 135 mg/l for chloride and 185 mg/l for sulfate under 80 percent control of Area VI. As a source of industrial supply, the Navajo Reservoir is definitely unsuitable for a number of industries, inherently inadequate for those having maximums that are near the accumulative average chloride concentrations of the reservoir, and suitable only for boiler makeup water and for brackish cooling water.

The maximum concentrations of sulfate in waters that have been used as sources of industrial supply range from 570 in process water of the petroleum industry to 2,700 mg/l in brackish[1/] cooling water in once-through systems are in the makeup recycle.

Sulfate concentrations in the Navajo Reservoir are estimated to range from a cumulative average of 655 to 760 mg/l over the 50 years of reservoir operation, assuming no control of Area VI. Compared with the maximums

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[1/] Water of more than 1,000 mg/l dissolved solids.

established within industry, this range of concentration is within the quality limits for boiler makeup water (1,400 mg/l maximum), and for those industries where brackish water is used for cooling in once-through systems and in the makeup recycle (2,700 mg/l), and in process water in the chemical industry (850 mg/l). The estimated sulfate concentrations exceed the maximums for fresh cooling water (680 mg/l) and for process water in the petroleum industry (570 mg/l).

With 80 percent control of Area VI, the estimated sulfate concentrations range from a cumulative average of 645 to 735 mg/l over the 50 years of reservoir operation. Quality control of Area VI, the prime source of sodium-chloride brine, reduces insignificantly the estimated sulfate concentrations in the reservoir. The suitability of the reservoir for industrial water supply with 80 percent control of Area VI is, therefore, the same as the suitability without control of Area VI.

Agricultural Supply

Livestock watering.- Water suitability for livestock depends upon such factors as the species of animals drinking the water, their sex, physiology, natural adaptability to changing water quality conditions, and upon the water content of their feed. Quality requirements have not been well established, probably because livestock generally have relatively high tolerance for saline water, and most water sources used to date have caused few problems. Such problems are not necessarily the consumption of lethal concentrations, but may arise from consuming water sufficiently saline to cause, for example, reduction in animal weight in beef cattle and reduced milk production from dairy cattle.

Chloride concentrations exceeding 4,000 mg/l reportedly have caused injury to livestock, whereas concentrations of 1,500 are assumed safe for cattle, swine, sheep and chickens.

Sulfate concentrations of approximately 2,100 mg/l have caused progressive weakening and death in cattle, whereas concentrations of no more than 1,000 mg/l are considered safe.

Chloride concentrations in the reservoir, under conditions of no control of Area VI, are generally less than the maximum recommended for livestock watering (1,500 mg/l). The cumulative average chloride concentrations in the reservoir range from 1,015 mg/l to 1,270 mg/l over the 50 years of operation.

With 80 percent control of Area VI, the water quality in the reservoir is suitable for livestock watering. The cumulative average chloride concentrations range from 430 to 540 mg/l over the 50 years of reservoir operation.

Sulfate concentrations in the reservoir, under conditions of no control of Area VI, are generally less than the maximum recommended for livestock (1,000 mg/l). The cumulative average sulfate concentrations in the reservoir range from 645 to 735 mg/l for the 50 year period.

Irrigation.- Water suitability for irrigation is dependent upon the type of crops to be irrigated, the characteristics of the soil in which the crops are grown, and the climatic conditions to which they are exposed. The complex interaction of the many factors that relate to soil (such as mineral and organic composition, texture and structure), to plants (salt tolerance at various stages of plant growth) and to climate (sunshine, rainfall, temperature, wind and humidity) will ultimately determine whether water of a particular quality will be suitable for irrigation. A final evaluation of the suitability of water for irrigation must, therefore, consider the interaction of soil, plants, and climate.

It is beyond the scope of this study to consider these factors as they apply to the study area in southwestern Oklahoma. However, a general classification of the water in the Navajo Reservoir is possible based on the Salinity Hazard Chart which correlates sodium-adsorption ratio (SAR) with the specific conductance.

Water containing sodium as the predominant cation can adversely affect soil structure and produce poor conditions of tilth. Potassium has similar affects, but generally occurs in very small concentrations and is often included in figures stated for sodium concentration.

The natural brines of Area VI contain high concentrations of sodium as exemplified by an analysis of spring water in Kiser Canyon in which sodium (and potassium) totals 120,000 mg/1.

SAR values were computed from sodium and calcium (plus magnesium) concentrations that are equivalent, respectively, to the estimated chloride and sulfate concentrations of the Navajo Reservoir. Table 11 lists the computed SAR values and the corresponding specific conductance figures for 5, 20 and 50 years of reservoir operation. Figure 8 is a diagram for the classification of irrigation waters. The significance of the S1 through S4 and C1 through C4 coding is discussed in Appendix F.

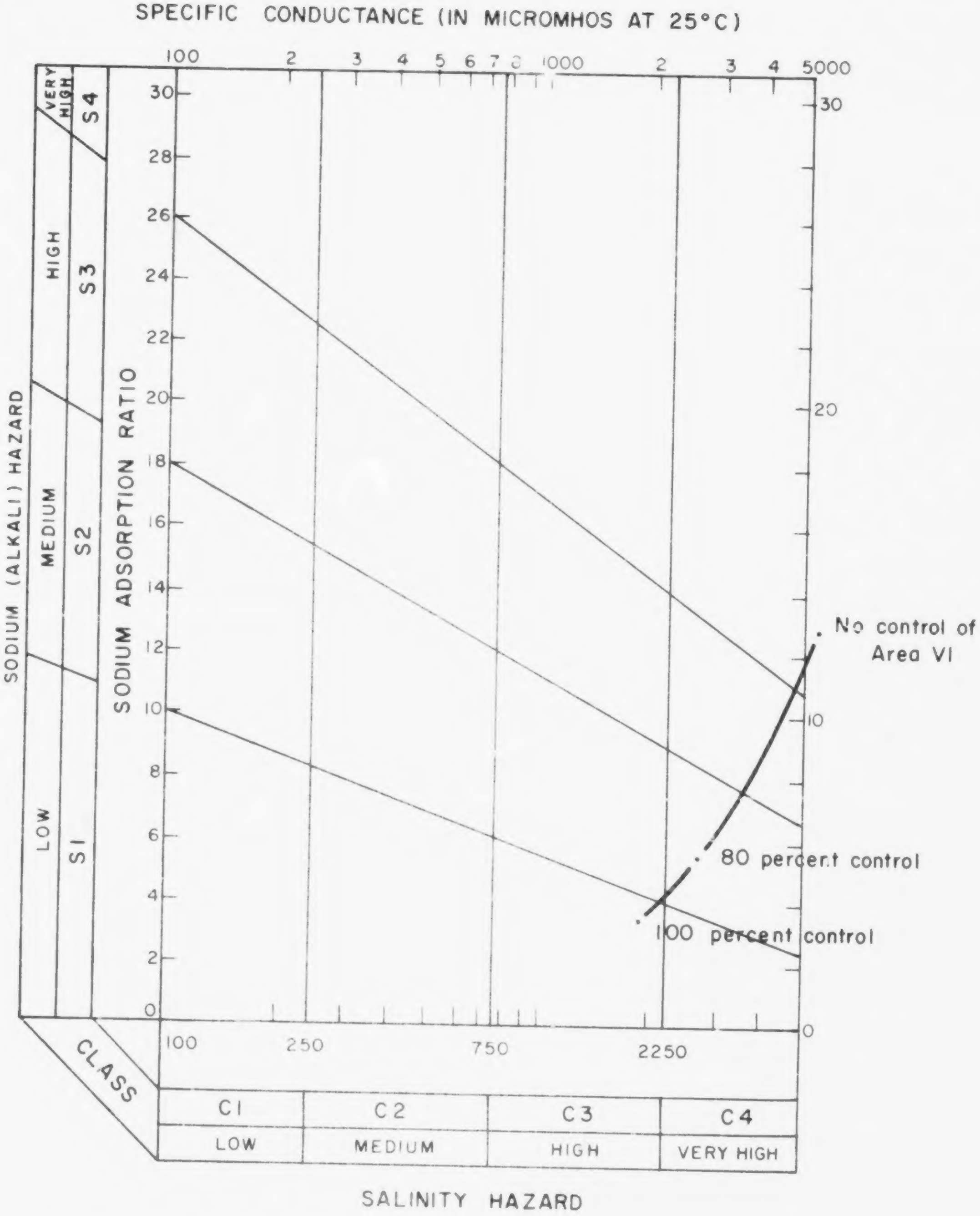
Table 11

FIFTY YEAR PROJECTION OF SODIUM-ADSORPTION-RATIOS FOR THE NAVAJO RESERVOIR

Control of Area VI on Elm Fork	Sodium-Adsorption Ratios and Specific Conductance Years of Reservoir Operation					
	5		20		50	
	SAR[1]	S.C.[2]	SAR	S.C.	SAR	S.C.
No control of Area VI	11.0	4,510	11.6	4,930	12.7	5,140
80 percent control	4.7	2,400	5.0	2,710	5.5	2,750
100 percent control	3.1	1,690	3.3	1,790	3.6	1,980

[1] SAR Sodium-adsorption ratio.

[2] S.C. Specific conductance (in micromhos/cm).



Classification of Irrigation Water from the proposed Navajo Reservoir
(Diagram from USDA, Agricultural Handbook No. 60)

FIGURE 8

Without control of Area VI the reservoir has a very high sodium hazard (S4) and an extremely high salinity hazard (C4) making it unsuitable as a source of irrigation water.

With 80 percent control of Area VI the reservoir has a medium sodium hazard (S2) and a very high salinity hazard (S4) making it unsuitable as a source of irrigation water except under very special conditions.

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Appendix A

DESCRIPTION OF SAMPLING STATIONS

Station No.	Location
754	Elm Fork at Salton Crossing, Oklahoma. Latitude 35°02', Long. 99°56' NE 1/4 SW 1/4, Section 3, T. 6 N., R. 26 W., approximately 2 1/2 miles above State Highway 30 at Salton Crossing, Harmon County, Oklahoma at about river mile 57 of the Elm Fork. (USGS Gaging Station No. 3034.00 located approximately 2 1/2 miles downstream from quality station).
753	Elm Fork near Carl, Oklahoma. Latitude 35 00'40", Long. 99°54'10", in SW 1/4 NW 1/4, Section 12, T. 6 N., R. 26 W., at bridge on State Highway 30, 4 miles NE of Carl, Harmon County, Oklahoma. River mile 54.0 of Elm Fork and drainage area of 416 square miles.
4	Elm Fork near Reed, Oklahoma. Latitude 34°58', Long. 99°42', on west line of Section 25, T. 6 N., R. 24 W., or downstream side of county bridge on FAS road, 1 mile upstream from Deer Creek, 4.2 miles north of Reed, and at about river miles 38 of the Elm Fork with a drainage area of 579 square miles.
5	Elm Fork - Mangum, Oklahoma. Latitude 34°56', Long. 99°30', on east line Section 10, T. 5 N., R. 22 W., at bridge on U. S. Highway 283, 3 miles north of Mangum, 5 miles downstream from Haystock Creek, and at river mile 17.8 of Elm Fork with a drainage area of 838 square miles.
490	North Fork of Red River near Headrick, Oklahoma. Latitude 34°28', Long. 99° 06', in center of N 1/2 Section 21, T. 2 N., R. 18 W., near left bank of downstream side of pier of bridge on U. S.

Highway 62, 2 1/2 miles east of Headrick, 12.9 miles upstream from Otter Creek, and at river mile 33.0 of North Fork with a drainage area of 4244 square miles, of which 399 square miles is probably noncontributing.

Appendix B

MONITORING AND SURVEILLANCE PROGRAM

The stream quality monitoring and surveillance program consisted of continuous specific conductance recording with continuous flow measurement. Weekly samples were collected and analyzed for correlation of specific conductance with chloride and sulfate concentrations.

Stream monitoring included five stations, which are shown in Figure 1. Using information obtained from the Monitoring and Surveillance Program, cumulative frequency curves (Figures 4 and 6) were derived by procedures set forth in Statistical Methods in Hydrology, by Leo R. Beard, January 1962.

Data computations were made by the Statistical Services Section, Sanitary Engineering Center, FWQA, at Cincinnati, Ohio, and by personnel of the Arkansas-Red River project.

Chemical analyses were made according to procedures set forth in Standard Methods for Examination of Water and Wastewater, 12th Edition, 1965, except sulfate determinations in FWQA laboratories where a modified turbidimetric procedure was used to improve analytical accuracy.

Appendix C

RECONNAISSANCE SURVEY

A field survey was made in March 1965, on the Elm Fork and its tributaries from Station 754 to its confluence with the North Fork and on the North Fork and its tributaries from Lake Altus to Station 490.

The purpose of the survey was to determine the location of additional stations for the Monitoring and Surveillance Program. Each tributary was investigated near their confluence with Elm Fork or North Fork. At each flowing tributary the flow was measured and a water sample was taken.

Daily records of Stations 753 and 490 were examined for a period of thirty days preceding and seven days following the survey period. The average chloride concentration was 10,600 mg/l with insignificant flow variations. The flow from Area VI is negligible and has no bearing on total flow at Station 490.

Appendix D

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 754

Location : Elm Fork at Salton Crossing, Oklahoma

Water Year : 1961

Basin : Red River

Tributary to: North Fork of the Red River

Remarks : Records poor Stratification nil.

Equations Used to Compute Constituents

Chlorides: $\log Cl = 1.5831 \log Sp.C. - 2.9227$

Sulfates : $\log SO_4 = 0.3986 \log Sp.C. + 1.6605$

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	•cfs	umho	cfs	umho	cfs	umho
1	16	6088	73	4311	44	5500	47	4531	37	5500	30	5350	72	4423	43	5788	21	8177	14	11295	12	8597	9	12743
2	16	5941	70	4500	44	5500	43	4740	33	5500	30	5438	68	4626	43	5970	35	7759	14	7930	11	9018	9	15789
3	16	6017	69	4550	44	5500	40	4849	32	5500	30	5413	63	4612	44	6000	706	2481	14	7345	11	9010	9	14970
4	16	6288	70	4600	44	5500	39	5029	33	5500	29	5381	60	4845	47	5825	107	2625	14	10643	11	8623	11	10296
5	16	6064	72	4650	44	5500	41	4830	29	5500	29	5388	60	4913	49	5047	95	2909	13	8296	10	8370	11	8417
6	16	6467	70	4700	44	5430	41	4875	37	5800	29	5369	58	4881	41	5077	111	3139	12	1555[illegible]	10	9378	11	8392
7	15	6638	69	4750	44	5500	41	4750	38	5600	29	5594	58	4813	36	6386	119	2799	12	1714[illegible]	10	9235	11	9232
8	14	7063	72	4685	44	5688	40	4737	35	5500	29	5450	62	4775	34	9058	106	2946	12	3770	10	9493	12	7868
9	14	6825	72	4500	47	5601	39	4654	33	5500	29	5488	62	4400	32	8571	74	3508	13	3081	9	10130	12	8111
10	14	6841	70	4500	54	5339	41	4812	36	4500	29	5625	57	4694	29	6227	57	5021	14	5112	9	10719	11	8626
11	447	1650	70	4500	63	4218	41	5004	34	4700	30	5613	54	4940	28	6231	47	4495	13	6876	9	10619	11	8475
12	1210	1700	70	4500	59	3978	41	5025	33	5000	30	5494	52	5127	28	6336	40	6543	12	8907	10	9266	11	9044
13	144	2600	70	4500	54	4379	41	5038	29	5206	29	5487	51	6106	27	6743	35	7451	12	4703	16	5068	11	8510
14	85	3200	70	4500	53	4669	40	4944	28	5390	28	5671	51	5431	27	7293	33	6921	12	6612	12	7005	11	7695
15	106	4200	70	4599	54	4675	40	4988	28	5388	28	5672	51	4944	27	8215	32	6750	11	5480	12	7483	12	7344
16	105	3650	68	4775	52	4800	37	5000	30	5249	32	6242	49	5106	28	7243	32	5625	11	5762	12	7603	12	7679
17	468	3600	66	4625	51	4525	37	5022	29	5200	72	5078	49	5250	28	6834	32	6307	11	3628	11	8273	11	8013
18	1700	1800	64	4600	49	4500	37	5149	30	4988	88	3221	49	5283	29	6574	29	6201	9	8928	11	8759	11	8059
19	347	2500	62	4600	48	4400	34	5237	29	5100	71	3691	49	5337	36	5324	27	6328	9	7954	11	8609	12	8430
20	149	2900	58	4699	48	4579	34	5370	32	5298	73	3512	48	5400	33	4026	25	6300	8	8360	12	6842	13	8592
21	112	2400	56	4800	45	4924	34	5376	41	5132	68	4209	46	5447	28	4800	23	6400	58	4629	12	6216	11	7539
22	109	3412	54	4885	48	4550	37	5215	42	4540	62	4587	46	5494	25	6000	21	6450	291	2500	12	8386	11	8376
23	105	3690	52	4912	47	4649	38	4970	37	4733	58	4681	46	5501	23	7000	19	6500	42	3000	11	8791	11	9587
24	92	6348	51	4913	46	4700	38	4985	35	5163	57	4831	44	5580	23	716[illegible]	19	6550	21	4600	11	9205	10	13343
25	106	3547	51	4862	43	4700	31	6218	32	5075	58	4884	41	5822	26	724[illegible]	19	6600	18	7416	11	8542	10	9999
26	38	3512	49	4913	41	4725	32	5760	33	5037	56	4816	41	5937	25	5922	19	6650	16	7204	10	8918	11	8475
27	88	3775	50	4988	41	4800	32	5000	32	5163	53	4800	43	5862	24	5940	17	6700	16	7455	10	9694	11	7959
28	38	3850	48	5000	41	4887	33	4770	30	5286	54	5133	43	5819	24	603[illegible]	17	7021	13	6764	10	9532	11	7456
29	87	3919	45	5228	41	4825	30	4386	--	--	56	5331	43	5813	24	5938	16	7431	12	7164	10	10175	12	7119
30	30	4000	46	5500	42	4902	34	4489	--	--	65	4680	43	5881	23	6912	15	10477	12	7819	10	10538	12	8647
31	75	4100	--	--	48	4843	41	4747	--	--	73	4528	--	--	22	8006	--	--	12	7991	9	11054	--	--
	192	2581	62	4697	47	4891	38	4975	33	5208	46	4818	52	5166	31	6347	65	386[illegible]	24	4988	11	8670	11	9018

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 754

Location : Elm Fork at Salton Crossing, Oklahoma

Water Year : 1962

Basin : Red River

Tributary to: North Fork of the Red River

Remarks : Records poor. Stratification nil.

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.5831 Log Sp.C. -2.9227

Sulfates : Log SO_4 = 0.3986 Log Sp.C. +1.6605

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	12	7769	40	6327	18	6740	15	5506	14	6000	13	7000	14	7250	60	6879	32	10199	16	9400	2468	1632	6	17006
2	12	7413	60	4500	18	6900	15	5453	14	6075	16	6800	14	7200	50	7147	29	8216	14	9600	130	2173	7	15866
3	12	7516	28	5500	18	6995	15	5316	14	6175	19	7500	15	7150	42	7183	27	7500	14	10300	64	3186	8	12863
4	12	7756	21	6313	18	6950	16	3912	14	6625	18	5800	16	7107	37	7082	13	7576	13	11200	52	4032	3	10156
5	12	8031	17	6242	20	6887	21	5581	14	6600	17	8000	18	7131	34	7106	53	7616	14	12002	37	4663	8	10499
6	12	9500	17	5979	20	7778	28	6362	14	6451	17	6550	21	7213	27	8532	25	6200	17	11663	29	5143	8	10162
7	12	11191	16	6336	19	6812	25	3672	15	6601	18	6475	20	7299	26	8534	14	6586	11	12316	24	5960	8	9428
8	12	9179	16	6691	20	7074	18	4696	15	6800	18	6375	18	7400	25	8378	16	6724	10	14500	22	6471	39	4780
9	17	8808	16	6633	21	6082	17	8581	15	6800	18	6324	18	7500	21	8598	127	5655	10	22000	20	6971	38	3600
10	15	8044	16	6812	20	6407	17	10445	15	6600	16	6722	18	7588	20	8774	73	4142	10	12500	18	7643	15	5617
11	12	8376	16	7013	19	10655	17	9311	15	6350	14	6800	18	7528	18	8800	23	5525	10	11412	16	8264	11	7109
12	12	8183	16	6559	15	7500	16	8410	16	6350	14	6800	17	7500	16	8800	14	6523	11	11613	15	10719	9	8333
13	13	8700	16	6486	13	5400	18	6888	16	6468	14	6800	16	7500	14	8800	10	7190	9	11270	16	10352	9	9250
14	12	8500	18	7789	12	5300	23	5262	16	6500	14	6800	15	7500	12	8800	8	7722	7	13983	16	9031	8	9939
15	12	7500	25	7783	11	5600	20	5447	16	6600	14	6800	14	7500	12	8970	2642	2268	6	15399	14	10343	14	6784
16	12	7800	25	7100	13	5700	19	5070	16	6800	14	6800	14	7500	15	9802	174	2492	6	16154	55	3099	73	3408
17	12	8000	24	7000	17	5700	19	5725	16	6975	14	6825	14	7500	36	8444	82	3737	6	16233	19	3470	611	2383
18	12	8000	21	7000	17	5700	17	4958	16	6900	14	7000	14	7500	34	6982	57	4939	6	16868	11	5568	67	2763
19	12	7500	21	7000	17	5751	18	6640	16	6700	14	7200	14	7500	18	7024	55	5114	6	17745	9	7600	44	4350
20	12	7000	21	7000	16	5802	23	6907	17	6549	14	7350	13	7500	14	7021	44	5608	6	17651	8	9800	1610	1889
21	12	7000	21	7000	15	[illegible]	20	6667	17	7500	14	7300	13	7500	13	7099	34	5659	7	14908	8	11500	150	1968
22	12	7200	21	6975	15	7700	17	6019	16	8700	14	7250	13	7500	14	8551	28	5719	10	10343	7	12023	68	2767
23	12	8200	20	7050	15	7120	17	5962	17	8200	14	7300	13	7550	10	8675	24	6683	40	5263	7	12907	54	3333
24	12	7600	19	6651	15	5682	19	5221	16	7500	15	7400	13	7634	10	8439	22	7694	612	2127	7	14125	42	3809
25	12	7500	19	6400	15	5289	21	4505	17	7100	15	7400	14	7390	11	8013	21	7725	230	2203	7	14450	60	3718
26	12	7413	19	6400	15	5098	25	3910	17	9500	14	7400	579	3893	[illegible]	7859	20	8806	54	4425	7	14500	47	3387
27	12	7373	19	6412	15	5483	19	4251	14	12000	14	7449	4471	2055	[illegible]	8667	19	9407	38	5716	7	14500	38	3971
28	13	6876	18	6554	15	10839	17	4872	12	12000	13	7850	223	1200	9	5702	19	9551	33	6800	6	15448	35	4422
29	13	7832	18	6600	15	7769	15	5061	--	--	14	6582	114	1800	[illegible]	3502	18	9200	32	7300	6	16060	31	4800
30	14	6313	19	6615	15	6155	14	5763	--	--	14	8050	79	6200	[illegible]	6624	17	9211	27	7400	6	16770	29	5000
31	15	7688	--	--	15	4865	14	6000	--	--	14	7388	--	--	[illegible]	9354	--	--	20	6700	6	17500	--	--
	13	7930	21	6490	16	5657	19	5862	15	7246	15	7074	195	2694	21	7887	125	7277	42	4634	101	2519	105	2657

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753

Location : Elm Fork near Carl, Oklahoma

Water Year : 1961

Basin : Red River

Tributary to: North Fork of the Red River

Remarks : Records fair. Stratification nil.

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.2762 Log Sp.C. -1.6867

Sulfates : Log SO_4 = 0.2809 Log Sp.C. +2.0156

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	16	24838	74	10113	44	12726	47	11897	37	11801	30	12563	72	8926	43	13513	21	17463	14	17751	12	22730	9	48092
2	16	25969	70	9638	44	13056	43	14949	33	8965	30	13822	68	10100	43	18317	35	12610	14	18013	11	24392	9	51703
3	16	27125	69	9725	44	13500	40	13487	33	8875	30	14207	63	10199	44	10942	706	4612	14	18727	11	24208	9	48821
4	16	31010	70	9784	44	13500	39	13260	34	10892	29	13766	60	11101	47	15069	107	2500	14	18867	11	27136	11	56890
5	16	33000	72	9562	44	13500	41	12601	29	19298	29	14225	60	12213	49	12783	95	9500	13	19149	10	29512	11	35617
6	16	32003	70	10199	44	13280	41	12693	37	20125	29	14344	58	11551	41	12428	111	4200	12	22986	10	31650	11	36925
7	15	31006	69	10100	44	13008	41	12226	38	13503	29	14940	58	11200	36	13894	119	1870	12	[illegible]	10	29316	11	43088
8	14	30003	72	10338	44	17000	40	11800	35	9728	29	14065	62	11419	34	11218	106	5076	12	20529	10	29360	12	32492
9	14	29000	72	9700	47	17000	39	12616	33	18000	29	14463	62	9495	32	12205	74	8793	13	24475	9	35272	12	29235
10	14	28000	70	10023	54	20000	41	13400	36	17500	29	14227	57	10483	29	15039	57	11554	14	15701	9	33959	11	34328
11	447	7000	70	10750	63	10000	41	13575	34	17000	30	12414	54	10515	26	15849	47	12368	13	16391	9	37248	11	33325
12	1210	2800	70	11000	59	9000	41	13525	33	16500	30	13553	52	8651	28	16000	40	12158	13	22246	10	35527	11	40050
13	144	1900	70	10775	54	10500	41	13575	29	16000	29	12884	51	9057	27	16500	35	12402	12	18860	16	14453	11	37975
14	85	1454	70	11225	53	11000	40	13550	28	15000	28	15225	51	10756	27	17000	33	12800	12	21742	12	24462	11	30359
15	106	1579	70	11944	54	11601	40	13403	28	14280	29	15913	51	11702	27	17500	32	13000	11	23580	12	23044	12	31412
16	105	1562	68	10421	52	11323	37	13526	30	14151	32	15749	49	9460	28	18000	32	13200	11	19259	12	22954	12	32528
17	468	1991	66	9999	51	11042	37	11776	29	12688	72	8618	49	10538	28	18150	32	13500	11	16430	11	25056	11	33978
18	1700	2407	64	10250	49	11280	35	10671	30	12922	98	1851	49	13037	29	16394	29	14000	9	21776	11	29388	11	32581
19	347	3483	62	10574	48	11420	34	9918	29	13150	71	2494	49	14349	36	14545	27	14500	9	26116	11	30524	11	35228
20	149	4600	58	10774	48	11540	34	13627	32	13496	73	4200	48	20000	33	12481	25	15000	8	26558	12	28663	13	31525
21	112	5000	56	11398	45	12108	34	14264	41	12787	68	5000	46	17000	28	15294	23	15929	58	9510	12	20213	11	24326
22	109	5200	54	11817	48	11811	37	15629	42	11078	62	7938	46	16000	25	16589	21	18394	291	4047	12	27191	11	32413
23	105	5600	52	11100	47	12349	38	12152	37	12142	58	7149	46	14000	23	17325	19	16768	42	5219	11	30706	11	38102
24	92	5600	51	11315	46	12415	38	13502	35	12847	57	7267	44	13000	22	16298	19	16467	21	10646	11	32681	10	35277
25	106	5700	51	11900	43	12689	31	33138	32	12055	58	7303	41	12500	26	18983	19	16671	18	15895	11	28811	10	33709
26	88	6786	49	11900	41	10662	32	29696	33	12023	56	7556	41	13194	25	15342	19	14723	16	16779	10	31215	11	29625
27	88	7388	50	11906	41	10850	32	37058	32	12251	53	8214	43	13019	24	14138	17	15101	16	19969	10	33888	11	34388
28	88	7575	48	12000	41	12023	33	14927	30	12917	54	9752	43	[illegible]	24	[illegible]	17	15051	13	21960	10	33367	11	32758
29	87	8572	45	12120	41	12669	30	16070	--	--	56	2100	43	[illegible]	24	[illegible]	16	16976	12	20821	10	37257	12	26338
30	80	9114	46	12876	42	13396	34	16242	--	--	65	11347	43	13244	23	[illegible]	15	17784	12	22500	10	40076	12	36007
31	75	9497	--	--	48	13149	41	14516	--	--	73	9321	--	--	22	17307	--	--	12	22940	9	43727	--	--
	192	4229	63	10732	47	12508	38	15224	33	13596	46	9427	52	[illegible]	[illegible]	15036	65	7789	24	11994	11	28999	11	35642

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753

Location : Elm Fork near Carl, Oklahoma

Water Year : 1962

Basin : Red River

Tributary to: North Fork of the Red River

Remarks : Records fair.

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.2762 Log Sp.C. -1.6867

Sulfates : Log SO_4 = 0.2809 Log Sp.C. +2.0156

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	12	32654	40	11146	18	20166	15	15167	14	20263	13	24452	14	19750	60	12860	42	29721	16	19385	2468	2351	6	36000
2	12	28778	60	7460	18	20125	15	19718	14	20058	16	17405	14	20560	50	13826	29	21088	14	19864	130	3504	7	39500
3	12	27164	28	10974	18	21025	15	17400	14	18213	19	19083	15	20214	42	14710	27	19658	14	22037	64	6246	8	38000
4	12	27985	21	15649	18	20562	16	20500	14	18275	18	25989	16	20614	37	14640	13	20378	13	24471	52	9002	8	36000
5	12	28150	17	16440	20	20802	21	20000	14	13575	17	21655	18	27069	34	14060	53	16418	14	30469	37	10913	8	35000
6	12	30081	17	18308	20	21078	28	22000	14	20367	17	20089	21	22922	27	15204	25	15904	17	28534	29	10441	8	34000
7	12	27124	16	21393	19	18216	25	16000	15	21196	18	21390	20	20198	26	17180	14	18757	11	24036	24	11904	8	33000
8	12	29048	16	23163	20	19873	18	16500	15	17375	18	20609	18	17147	25	17865	16	24076	10	27130	22	13116	39	18087
9	17	26211	16	23385	21	19170	17	33000	15	17000	18	17298	18	19529	21	18619	127	11562	9	26605	20	14395	38	8110
10	15	24315	16	21997	20	16278	17	40000	15	19214	16	19530	18	21231	20	18520	73	7386	9	29628	18	16348	15	15679
11	12	28893	16	21594	19	22398	17	40000	15	18332	14	20432	18	20734	18	19111	23	16661	10	30746	16	18206	11	18950
12	12	26489	1	21321	15	30000	16	39000	16	19375	14	19271	17	22222	16	17089	14	19192	11	28998	15	20909	10	22000
13	13	26912	16	19454	13	28000	18	23000	16	18349	14	21500	16	18626	14	18924	10	19585	9	22536	16	25197	9	24000
14	12	22996	18	25760	12	17000	23	16000	16	18250	14	20500	15	19187	12	20986	8	20203	7	34371	16	21301	8	25000
15	12	24190	25	19373	11	15000	20	15000	16	19963	14	20000	14	20979	12	21643	2642	5100	6	37452	14	22120	14	30000
16	12	23548	25	14777	13	17000	19	13908	16	18000	14	24000	14	22713	15	21365	174	5420	6	40309	55	9793	73	15000
17	12	26728	24	18469	17	19500	19	17092	16	20250	14	24500	14	24208	26	25068	84	6660	6	39764	19	5653	611	6000
18	12	27435	21	21379	17	18500	17	17619	16	20625	14	33000	14	21755	34	16433	[illegible]	8403	6	39663	11	13061	67	7300
19	12	28650	21	22144	17	17000	18	27513	16	21876	14	28000	14	22523	18	17049	55	9477	6	40488	9	19387	44	8730
20	12	32487	21	21750	16	19854	23	28416	17	28000	14	30000	13	23818	14	17537	44	11081	6	46000	8	26264	1610	2980
21	12	21131	21	22641	15	19697	20	23389	17	32000	14	27169	13	24438	13	17996	34	12035	7	39388	8	28530	150	2830
22	12	21334	21	22351	15	16994	17	21056	16	24000	14	20456	13	25125	14	19396	28	12923	10	24093	7	26596	68	4860
23	12	22375	20	20404	15	16257	17	19812	17	20000	14	20052	13	24250	10	20752	24	14512	40	15351	7	25018	54	6115
24	12	23587	19	20766	15	18829	19	15308	16	19000	15	25461	13	26144	10	[illegible]	22	15344	612	4000	7	29180	42	7669
25	12	23188	19	18600	15	19913	21	10699	17	20000	15	29569	14	24074	11	25182	21	15714	230	2700	7	31065	60	8691
26	12	21629	19	19425	15	18952	25	9341	17	16500	14	26038	579	6129	9	[illegible]	20	17383	54	9000	7	25948	47	8200
27	12	21712	19	20556	15	19687	19	10121	14	25000	14	27002	4471	2249	9	23546	19	18215	38	17000	7	27830	38	9000
28	13	15309	18	21615	15	19745	17	12909	12	26116	13	22446	223	4572	9	[illegible]	19	17000	33	20352	6	30000	35	11000
29	13	17768	18	18724	15	22339	15	14324	--	--	14	23988	114	6931	8	[illegible]	18	17407	32	20583	6	32000	31	13000
30	14	24876	19	19769	15	20821	14	17468	--	--	14	23563	79	10111	8	[illegible]	17	19792	27	18694	6	33000	29	13000
31	15	23455	--	--	15	13867	14	19750	--	--	14	20846	--	--	7	24195	--	--	20	17189	6	35000	--	--
[illegible]	13	25311	21	18136	16	19670	19	20134	15	20433	15	22918	195	4215	21	17619	125	[illegible]	42	10026	101	4478	105	5911

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753
Location: **Elm Fork of North Fork Red River**
near Carl, Oklahoma
Water Year: 1963

Basin: **Red River**
Tributary to: **Red River**
Remarks:

Equations Used to Compute Constit[illegible]:
Chlorides: $\text{Log Cl} = 1.26407 \text{ Log Sp.C.} - 1.61783$
Sulfates: $\text{Log } SO_4 = 0.21096 \text{ Log Sp.C.} + 2.31115$

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho
1	26	12800	22	19500	25	18000	24	12000	22	14500	21	20000	22	22000	12	30000	452	2120	1.4	26000	0.7	105000	35	12000
2	26	12800	22	19200	34	17500	23	12800	22	14500	22	18000	21	17200	13	29000	192	3930	1.1	30000	.2	115000	20	26000
3	25	14000	22	18000	41	12300	24	13000	20	14500	20	16000	18	18500	13	28500	527	2200	1.1	33000	.1	120000	11	38000
4	24	13500	22	18500	30	15000	26	17000	22	13000	21	19000	17	21000	12	28500	82	3470	.9	35000	.1	115000	8.2	35000
5	29	17200	22	17800	25	15800	25	16200	25	14000	20	18200	21	26000	14	34000	267	3100	.5	42000	.3	100000	7.4	40000
6	33	16000	22	20000	24	17200	23	17500	25	15200	19	17500	23	18000	14	26000	56	4500	.5	40000	.5	125000	6.7	41000
7	25	15000	22	17800	24	16800	23	17800	23	16000	20	16800	22	18500	14	26000	28	8200	.5	42000	.7	163000	3.1	54000
8	23	15500	22	17000	24	16200	22	17300	22	14300	19	16200	19	20500	12	31000	140	3650	.7	46000	2.3	135000	2.3	57000
9	22	15800	22	18000	23	14000	22	18000	22	14800	18	16000	18	20500	11	32000	76	6000	.5	43000	2.3	115000	2.3	57000
10	23	15500	22	20500	23	13800	22	17000	29	19000	22	20500	16	21500	9.7	35000	37	17000	.4	52000	5.3	92000	2.7	60000
11	22	14300	23	18000	25	18000	15	45000	25	20000	22	18200	16	23000	8.7	38000	26	31000	.4	54000	2.3	94000	3.6	58000
12	20	16000	22	16300	23	16800	12	45000	23	18000	19	18000	16	22500	8.7	40000	132	10600	15	38000	1.7	100000	5.3	35000
13	20	18500	22	17000	23	16200	12	36000	23	18000	18	19000	14	23000	8.7	34500	70	13500	7.4	39000	11	82000	6.7	30000
14	18	17200	22	18500	25	17000	14	33000	24	16500	18	19000	14	23000	7.9	39000	50	14000	6.7	35000	5.3	60000	6.7	38000
15	19	17500	23	17500	25	17500	14	24000	22	17500	18	18000	14	22000	7.9	42000	36	15000	6.7	27000	4.1	48000	15	25300
16	18	18000	24	18500	23	16500	15	20500	28	20000	17	20000	13	21000	8.7	40000	30	17000	4.7	32000	2.0	75000	463	4350
17	21	20000	29	18500	22	15000	15	16000	29	16300	17	19000	14	25000	8.7	28000	24	18000	3.1	52000	1.1	55000	48	13000
18	24	17500	33	15200	22	15200	16	13000	26	16000	16	21000	14	28000	7.1	37000	20	19000	3.1	61000	2.7	45000	30	15000
19	36	16900	30	15800	22	17800	14	20000	25	14000	18	18000	13	22000	7.1	37000	19	19000	2.7	60000	4.1	43000	16	18000
20	112	10100	28	17500	22	17800	15	22000	22	16000	17	18000	12	23000	7.1	38000	14	17000	2.7	63000	6.0	32000	12	18500
21	34	13500	28	18500	22	18500	16	16500	21	16500	18	19000	12	24500	7.9	37000	11	19000	2.0	58000	2.7	50000	10	21000
22	24	17000	26	16500	22	19800	16	15000	20	19500	18	18000	11	28000	8.3	34000	12	20000	1.1	62000	1.4	66000	9	21000
23	22	17000	25	14500	21	21000	15	15500	22	16500	17	20000	11	28000	8.7	32000	11	23000	.4	70000	.7	86000	8	25000
24	20	16500	24	18000	19	21500	16	15500	22	17000	17	21000	17	31300	9.7	33000	7.4	18000	.4	75000	2.3	104000	8	36000
25	19	17000	24	14300	19	22500	17	16500	22	18200	17	19000	15	20500	9.7	30000	5.3	19000	.4	77000	8.4	51500	7.4	35000
26	19	18000	72	10800	17	22800	18	17500	22	18500	16	19000	14	25000	8.7	32000	5.3	19500	.2	86000	8.5	21300	7	32000
27	21	17000	62	9000	18	20000	16	19000	21	19000	16	18000	14	27000	7.9	33000	4.1	27000	.4	88000	12	25000	6.7	34000
28	24	18000	34	14800	31	13300	18	17500	21	19000	16	20000	14	25000	6.8	37000	3.1	26000	.9	90000	4.1	48000	6.7	34000
29	22	17500	28	16300	26	15000	20	15200	--	--	17	19700	13	24000	11	[illegible]	1.7	27000	2.3	92000	3.1	55000	6.7	36000
30	22	16000	25	16700	24	15200	18	16500	--	--	18	19500	12	26000	592	2750	1.4	22000	3.1	93000	4.7	46000	6.7	38000
31	21	19200	--	--	24	14800	22	17000	--	--	18	20000	--	--	388	[illegible]	--	--	2.3	93000	7.4	35000	--	--
Mean	26	15400	28	16100	24	16800	18	18800	23	16700	18	18700	16	22800	40.8	350	78.0	5850	2.4	47900	3.5	57100	26.0	12700

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753
Location: Elm Fork of North Fork Red River Near
Carl, Oklahoma
Water Year: 1964

Basin: **Red River**
Tributary to: **Red River**
Remarks:

Equations Used to Compute Constituents:
Chlorides: LOG Cl=1.27192 LOG SC-1.64507
Sulfates: LOG SO_4=0 32935 LOG SC + 01.81378

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho
1	6.7	35000	11	35000	14	26000	15	21000	19	20000	15	23500	12	24200	8.2	31000	19	22000	10	32500	1.7	127000	0.1	210000
2	6.7	35000	9.8	29000	14	25500	14	22500	17	22300	15	23500	11	25300	6.7	30500	17	22000	8	36500	0.7	150000	0.1	210000
3	6.7	36000	9.8	32000	14	26000	13	19500	21	27200	15	23300	12	26200	6.0	30000	13	25000	7	37000	0.3	160000	0.1	215000
4	6.7	35000	11	30500	15	26000	13	21500	53	17300	15	23000	12	25900	5.3	31000	13	30500	6	42200	0.3	185000	0.1	215000
5	5.3	35000	11	30000	15	27500	13	22500	53	13100	15	21700	12	23800	5.3	41000	12	26500	4.4	44000	0.2	190000	0.3	215000
6	5.3	34000	11	29500	15	27000	13	20000	37	14500	14	21600	12	23500	465	5600	11	29500	3.8	49000	0.2	185000	0.4	215000
7	6.0	34000	11	31000	15	32000	13	22000	26	19800	13	23800	11	23500	51	6950	7.4	35500	3.6	54000	0.1	190000	0.2	215000
8	6.0	35000	11	36000	15	40000	13	20500	23	17000	14	25500	11	32500	19	6200	6.0	36000	3.6	54000	0.2	190000	0.4	215000
9	6.0	36000	11	30000	15	40000	8	28000	23	18200	14	24500	11	24000	14	5310	5.3	36500	3.6	61000	0.4	195000	0.4	215000
10	6.0	31000	11	24000	15	41000	9	28500	21	19500	14	22100	11	25000	697	4070	4.7	38000	3.6	68000	0.3	190000	0.3	215000
11	6.0	34000	11	27000	13	37000	8	23200	19	20500	14	21300	11	30000	265	2720	14	30700	3.4	71000	0.1	190000	0.3	215000
12	6.7	35000	9.0	28000	11	40000	7	42000	19	23500	14	23000	9.8	31000	43	5320	41	10800	3.0	73000	0.1	190000	0.4	210000
13	6.7	36000	9.0	38500	9	27000	6	35000	19	21500	14	24300	9.8	25500	28	8230	1500	3820	2.4	75000	0.1	190000	0.7	210000
14	7.4	40000	9.0	29000	6	17000	11	34000	20	21800	13	23000	12	25500	21	7000	1550	3050	2.0	76000	1.1	200000	0.5	210000
15	8.2	42000	9.8	28500	7	19000	10	29000	21	24000	13	26000	11	27500	19	10800	367	5200	2.0	76000	20	128000	49	72000
16	9.0	40000	9.8	29700	8	27000	12	27000	21	21000	13	25000	11	32500	17	11500	178	8550	2.2	83000	11	96000	154	18500
17	9.0	37000	9.8	29000	8.5	23000	14	22000	20	22800	13	23500	11	36000	14	18000	137	10700	2.3	88000	7.4	97000	17	32000
18	9.0	37000	11	27500	9	23000	17	19000	19	22800	13	28300	9.8	44800	13	18800	100	11500	1.7	88000	5.3	110000	8.2	53000
19	9.0	34500	23	30000	9.5	24000	19	12000	17	22500	20	25000	11	76000	11	19500	50	12500	1.1	95000	3.6	120000	3.1	71000
20	16	45500	20	20200	10	18500	21	17000	16	22800	17	18200	9.0	40000	9.8	18000	28	16000	0.9	103000	2.0	135000	20	43000
21	11	33000	20	26500	9	37000	20	18500	16	24200	16	20400	8.2	25000	9.0	24000	20	18700	0.7	105000	1.7	150000	4.1	68000
22	11	31500	19	26000	8	54000	16	18200	15	24000	14	22400	8.2	34000	9.0	24000	18	21000	0.7	125000	1.4	160000	4.1	75000
23	11	34000	14	26500	10	27500	15	19000	16	21000	14	23200	8.2	31500	8.2	25000	17	23000	0.7	130000	0.5	160000	3.6	74000
24	11	30500	14	28000	14	17000	14	19000	15	20500	14	24000	8.2	31500	8.2	28500	16	25000	0.5	122000	0.3	180000	3.6	72000
25	9.8	30000	14	28500	17	14000	13	23000	15	21800	12	26300	8.2	29000	7.4	27000	14	26000	0.3	130000	0.2	200000	6.0	70000
26	9.8	30500	14	27000	20	16000	16	21500	14	22300	12	25500	6.7	32000	6.7	27000	13	25200	0.2	150000	0.2	200000	5.3	68000
27	9.8	32000	14	27500	15	22000	16	20000	15	21300	12	26300	7.4	31500	26	40700	12	27200	2.0	170000	0.1	200000	7.4	76000
28	9.8	32000	14	27500	13	23000	15	20500	15	21000	12	26200	7.4	32000	35	23600	11	28500	0.4	180000	0.1	205000	4.7	80000
29	9.8	33000	13	28000	14	23000	15	21000	15	21800	12	26200	7.4	31800	26	28400	11	30800	0.5	180000	0.1	205000	4.7	76000
30	9.8	32500	13	27500	16	21500	19	26000	--	--	11	25300	8.2	32000	33	16000	11	32200	1.7	142000	0.2	210000	4.7	68000
31	9.8	32000	--	--	15	20000	21	23000	--	--	12	24300	--	--	23	18000	--	--	3.6	85000	0.1	210000	--	--
Mean	8.4	34900	13	28200	12	26900	14	22000	21	20100	14	23700	10	30500	62	7480	141	5930	2.8	63700	1.9	123000	10	42300

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753

Location : **Elm Fork of North Fork Red River near Carl, Oklahoma**

Water Year : 1965

Basin : Red River

Tributary to: Red River

Remarks : *discharge measurement made on this day

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.22916 Log Sp.C. -1.43934

Sulfates : Log SO_4 = .23475 Log Sp.C. +2.22941

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	5.3	69500	8.2	41500	19	30100	14	29600	13	30800	16	37000	14	29100	7.4	36100	2.7	79100	24	18200	2.7	61300	5.3	99100
2	5.3	65000	8.2	43500	20	28400	14	27800	11	37900	14	33200	15	29100	8.2	34400	291	24300	21	17100	2.3	75100	3.6	101000
3	6.0	63000	8.2	40900	20	29200	11	24500	12	27900	17	26700	15	28200	7.4	37400	466	*8740	19	20300	2.3	69300	3.6	109000
4	4.7	68500	9.0	46000	9.0	43700	11	25400	13	22800	16	27800	13	30800	6.7	41500	3660	2000	16	19300	1.7	71000	2.7	119000
5	4.7	77500	16	43000	15	29400	12	28800	14	24500	16	24200	14	30700	6.0	41900	1930	2530	15	19300	1.1	79900	32	110000
6	4.7	86300	*15	45300	16	26800	12	30200	13	28800	15	24000	13	28500	5.3	46400	100	5300	13	20500	1.1	98900	644	18800
7	4.7	87400	13	33100	12	27100	9.8	24900	13	25800	13	26200	16	31700	4.1	53800	60	7930	11	21600	2.3	100000	69	13300
8	5.3	77300	9.8	34800	11	28700	12	25600	*13	28200	13	26200	16	31000	3.6	46700	50	10400	9.8	26900	1.7	93300	33	27200
9	5.3	85600	9.0	35300	13	25200	13	30400	17	32000	13	26300	26	29600	3.1	46000	*46	12900	9.0	27600	3.8	77400	23	36700
10	5.3	91000	9.0	37800	28	25000	15	30700	16	26300	13	27100	50	11500	8.2	58500	39	14000	8.2	29300	3.1	74000	19	41100
11	6.0	89500	8.2	39800	*26	18600	15	25900	15	27000	14	30800	14	24000	7.4	40900	41	16800	6.7	28000	*2.3	87000	16	48300
12	6.7	73400	7.4	36800	16	22600	*15	24400	12	34800	19	29400	11	24000	6.7	31000	35	14900	6.0	29500	2.7	108000	15	50800
13	6.0	60300	7.4	37000	13	25000	14	23500	14	23600	20	23400	9.8	31000	9.0	39600	505	13200	6.0	33100	2.3	117000	14	54500
14	6.0	56500	8.2	37900	11	28700	13	22400	13	27600	17	22300	*662	16700	9.8	36900	94	5160	6.0	36600	2.3	126000	12	66500
15	6.0	56100	124	2620	11	27600	13	26200	13	24800	16	23000	* 62	13700	8.2	33300	639	3890	*6.0	41600	5.3	116000	11	73600
16	5.3	56300	229	7610	14	25400	13	26400	12	31200	15	28400	14	15800	7.4	38200	*224	4120	6.0	40700	8.2	60800	9.0	71500
17	5.3	59300	291	4300	11	42400	12	30100	15	24800	16	25100	11	17500	6.0	45400	63	6980	5.3	42900	6.0	65900	9.8	70000
18	4.1	53100	88	9720	12	44700	13	26000	14	24900	14	28300	9.8	18800	5.3	47700	41	8680	4.7	42800	4.7	74400	19	59000
19	3.6	58900	33	14300	15	32700	13	27600	14	24400	14	28400	9.0	22000	11	46800	29	10000	3.1	45900	5.3	79200	209	12200
20	4.1	66600	20	19400	20	25200	13	26600	13	26300	13	27800	8.2	27000	*8.2	54500	21	11000	2.7	53700	5.3	74300	556	9730
21	4.7	64100	15	21000	*23	18500	13	27100	13	26300	15	25700	8.2	31100	5.3	60700	17	12700	2.3	59800	3.6	87000	620	3450
22	4.7	60600	14	21700	15	24400	13	28400	12	33400	15	28400	7.4	33800	4.7	69000	15	15200	1.7	64600	3.1	88400	54	7760
23	4.7	58100	15	22200	12	27100	13	27600	*8.2	38700	*14	27100	6.0	36800	4.7	73000	16	12800	1.4	70000	3.1	86300	29	18700
24	9.0	60900	16	26100	11	26700	12	30600	9.0	68100	14	29000	6.7	39900	5.3	72900	11	17000	1.4	76300	55	24400	*21	23000
25	92	22100	*16	28500	9.8	26800	*12	28400	13	42300	14	30100	6.7	39100	4.1	72100	215	11100	1.4	80800	9.0	34500	20	24000
26	46	18200	17	27000	9.0	26800	12	26600	16	21600	14	29600	12	28600	33	27700	254	4060	1.4	92800	3.1	73300	19	25000
27	19	35500	19	29200	9.0	24500	11	26100	14	25400	15	27500	*11	29700	12	24000	77	6910	1.4	86600	2.0	94000	17	26400
28	13	60400	20	28400	9.0	27400	12	30400	13	29000	14	28300	11	30100	7.4	31700	48	12700	23	40100	100	90000	15	29500
29	12	73200	20	26800	9.0	27900	12	33000	--	--	15	27000	9.0	31300	5.3	70300	37	17100	9.0	38000	23	84500	15	29700
30	9.8	45000	19	28800	9.0	27000	13	27300	--	--	14	28200	8.2	35000	4.7	7440	29	18900	4.1	39900	*6.0	83000	15	30300
31	8.2	43600	--	--	11	27400	13	30000	--	--	14	28600	--	--	3.6	7740	--	--	3.1	48600	6.0	91200	--	--
	10.6	45000	36.4	13700	14.2	27300	12.7	27500	13.2	29200	14.9	27500	37.0	19700	7.39	44600	302	5070	8.02	29900	9.3	73200	84.4	16300

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753
Location : Elm Fork of North Fork of Red River near Carl, Oklahoma
Water Year : 1966

Basin : Red River
Tributary to: Red River
Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.13376 Log Sp. C. - 1.00727

Sulfates : SO_4 = 0.0126 Sp.C. +1384

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	13	28200	24	20800	26	18600	24	22000	4.5	25700	23	22400	16	27000	17	28800	8.2	49100	4.1	68400	2.0	84100	521	5460
2	13	29000	23	21700	26	21300	24	20800	4.0	22600	21	19600	16	26400	16	26500	9.8	45800	3.6	77500	1.6	101700	84	13900
3	13	30100	23	20000	20	20800	24	18300	3.5	19800	20	21300	15	26200	14	25500	8.2	50900	2.7	78500	1.4	127900	146	15700
4	14	31300	23	21600	19	23300	24	18300	3.0	18300	20	21500	15	28300	13	29100	6.0	67400	2.0	86000	1.7	137000	421	6210
5	17	32400	23	20700	17	23200	24	21400	6.7	15200	20	23000	15	24700	13	25700	4.0	75000	2.0	96000	0.9	147500	76	10900
6	16	29200	23	20200	19	22500	24	19000	28	14000	19	21600	15	22400	13	25300	3.0	88750	1.7	110600	0.7	157500	41	16600
7	14	30700	23	21100	19	21800	24	18800	28	17100	20	22100	15	22800	13	27500	2.3	97100	1.4	125500	4.1	145000	35	15200
8	12	34200	23	21800	19	21500	23	21100	29	17800	20	19500	15	24900	13	30400	2.3	104000	1.4	132500	2.0	117600	33	17400
9	11	35400	23	22600	20	23800	23	22000	26	19900	20	20700	15	28300	13	29200	2.0	111250	1.4	155000	8.3	54600	26	19500
10	9.8	34800	23	21900	21	24000	23	22900	21	21600	20	19900	15	27800	13	30900	2.0	116750	1.4	164000	12	29100	24	20000
11	9.0	34000	23	21600	21	22400	23	23800	21	21500	20	21300	15	27500	13	33500	2.3	122750	13	50400	6.0	54400	24	20100
12	9.0	36800	21	22100	17	22500	23	23000	20	20600	20	23500	15	25800	13	27500	2.3	121000	3.1	45900	2.0	69800	23	21100
13	9.0	37500	21	23400	17	22900	21	22900	20	21250	20	25500	17	24800	13	30800	2.3	114500	1.1	79800	5.6	46600	23	23200
14	9.8	35800	26	22600	17	22700	21	23800	20	25100	20	22600	16	26900	12	28500	2.3	118000	0.7	119500	12	23300	21	26100
15	9.8	34800	26	21000	16	22000	21	22800	21	24200	21	20700	16	28900	12	32500	2.3	122700	0.5	132500	7.4	52600	89	26400
16	12	32300	24	21000	17	21800	23	21600	20	20200	21	23000	16	31000	12	32400	2.7	109700	0.4	144500	7.4	84800	118	14400
17	804	26600	23	20600	17	21300	20	28600	20	18400	21	25500	16	29300	11	39100	6.7	100600	0.3	160500	4.1	76600	695	8690
18	2060	2840	21	22100	19	21400	18	24800	19	19100	20	26500	16	28500	11	35800	9.0	52600	0.3	165500	41	74000	327	4440
19	174	5220	21	23000	19	21200	25	23000	21	20100	20	26800	17	25000	11	39100	8.2	40500	0.3	176300	693	5180	23	11400
20	85	8260	23	24100	19	21400	33	15400	21	20800	20	25800	17	22200	11	42800	5.3	48500	0.2	183700	93	12300	17	16200
21	55	12000	24	25100	19	19500	24	29000	23	23300	20	24800	17	25900	11	38100	10	52400	0.2	177500	95	13900	16	17800
22	48	13100	24	23300	19	18200	21	41600	23	21600	20	26400	33	37200	9.8	40000	27	30700	0.3	145000	108	15700	15	18300
23	43	13700	24	20400	24	21500	18	25000	20	18500	19	25200	41	19500	9.0	43000	9.0	42600	4.7	104000	722	5000	14	21700
24	39	15900	23	20100	31	21500	15	21600	20	17200	19	27700	31	17900	7.4	48800	5.3	55800	734	20100	295	3900	12	23100
25	37	17800	23	20500	24	19000	23	20100	20	18800	19	26000	23	26700	7.4	53400	3.1	68400	153	3610	77	11400	12	20500
26	33	18000	21	[illegible]	20	20100	20	22300	20	20700	19	24800	20	23900	7.4	47100	2.7	87200	33	31400	53	17600	11	24300
27	31	18500	20	20000	19	20200	18	22400	29	23700	19	24800	17	17000	8.2	45200	47	50400	14	34900	33	21100	300	14500
28	29	19000	20	20000	19	21200	14	25400	28	22000	19	23300	15	21900	8.2	4420	24	23900	9.0	46600	21	22000	100	3215
29	28	19100	21	18900	19	21300	10	26000	--	--	19	23000	14	29700	9.8	382	11	36400	6.0	64300	15	22000	40	11800
30	26	17700	23	16600	19	21700	5.0	21700	--	--	17	26000	14	27900	11	309	6.7	50600	4.0	67200	13	23300	39	14900
31	24	19800	--	--	23	21800	5.0	23700	--	--	16	27000	--	--	9.0	4660	--	--	2.7	76400	685	19200	--	--
	120	11200	22.8	21300	20	21400	20.6	22700	19.3	20200	19.7	23500	17.9	25700	11.5	3390	7.9	53800	32.3	22000	99.1	13300	111	10200

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 753

Location : Elm Fork North Fork Red River
near Carl, Oklahoma

Water Year : 1967

Basin : Red River

Tributary to: Red River

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.12491 Log Sp.C. -1.00846

Sulfates : Log SO_4 = 0.28983 Log Sp.C. +1.92989

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	30	18300	15	24800	20	25100	19	29300	20	27900	17	29600	14	32500	12	25100	31	9330	14	22600	9.0	35800	6.8	67800
2	26	19100	16	25300	20	25000	21	26700	20	27000	16	29200	15	30600	11	27000	26	12200	11	25000	7.8	29800	7.3	60000
3	26	18800	18	25800	19	24500	15	27200	20	22900	17	26000	14	24600	9.0	30000	24	18000	162	32100	7.7	33300	12	53600
4	24	20400	19	26400	20	23800	17	23800	19	25600	17	28100	12	30400	9.8	30300	20	21600	2030	2450	17	40200	500	8000
5	25	21800	19	27900	20	21100	19	21200	19	27300	16	28800	12	26600	572	35800	18	25100	163	11500	29	23500	112	8100
6	24	13900	19	28000	20	24500	22	21000	15	29000	17	30200	11	28700	682	4490	16	28300	63	15000	17	23800	77	15200
7	24	24200	19	26400	20	25200	15	26500	17	24700	16	24600	10	21300	67	3880	16	28500	42	14300	9.5	24300	73	12500
8	21	24500	18	25400	17	23500	13	35100	19	20400	12	31500	11	32700	43	8490	14	28500	30	14000	6.0	31500	39	13100
9	20	23500	17	25800	19	19000	12	38100	19	22300	15	21100	12	34500	41	13100	9.9	38500	22	15000	5.0	35100	30	17600
10	19	22300	18	26200	16	22800	20	22400	19	24900	17	19500	12	33400	31	13300	7.4	40000	17	18000	4.2	45800	22	27400
11	20	22100	19	25900	18	23800	21	18900	20	21000	16	25400	25	36500	28	13500	6.4	52400	12	19300	3.8	45600	17	32300
12	20	24600	19	24800	20	17300	26	16300	19	21900	14	27600	1630	6350	25	16100	5.4	51400	9.2	19300	3.5	46700	12	35600
13	19	22600	18	24900	17	21100	22	19300	18	21100	12	26500	598	3410	25	19000	5.0	44100	7.0	24500	2.9	54400	10	34900
14	18	22900	18	25800	19	17800	21	23800	17	26600	12	26000	111	5040	24	20000	4.5	48500	5.0	28300	2.6	62300	20	48100
15	16	22400	18	25700	20	20300	20	24200	17	25600	11	27200	67	9540	20	18600	4.7	51500	4.2	29800	1.9	62900	15	36800
16	17	23300	18	25300	17	23300	20	25500	16	24000	11	29900	57	13200	17	20100	3.9	48500	3.6	31500	4.3	56200	12	44800
17	28	31300	18	22600	16	25400	19	24000	17	22700	11	28600	50	15600	15	23700	2.8	48500	3.5	32500	7.2	39200	12	36400
18	31	22400	18	20700	17	25000	16	32600	17	28000	10	30100	45	17800	12	25400	3.9	50000	4.0	33700	5.[illegible]	41900	11	35600
19	27	21400	18	22000	17	22900	16	32200	18	26000	18	40200	41	19000	12	26800	5.1	49000	567	12800	4.7	46100	10	31500
20	22	25000	18	22300	16	23200	22	22800	17	26500	48	29000	41	17600	13	30000	2.9	51300	194	5600	3.5	54300	1470	13100
21	21	22500	18	23800	15	24400	23	19800	16	23000	28	17200	35	18300	12	29100	2.1	59100	77	9300	24	42400	669	2750
22	18	23700	19	23300	15	23800	20	21900	17	22200	18	22300	30	19200	11	24300	2.0	75000	39	12300	9.9	32300	114	4900
23	16	20800	18	22100	9	43200	19	25500	17	21300	16	27100	26	21500	10	27800	1.6	86000	31	16400	5.1	34700	56	8400
24	17	23100	18	21200	10	46000	19	25900	15	23300	14	29700	24	24000	9.9	29600	2.0	80500	25	19400	4.1	47300	40	10300
25	17	26100	19	22700	12	32400	19	25500	16	19500	17	24800	22	24400	8.2	34100	647	16000	21	21800	3.9	64300	34	13800
26	16	26000	20	26100	12	31200	18	26300	18	21900	16	28300	20	22100	7.3	37200	118	6280	20	22700	3.1	70500	28	12500
27	16	23100	18	23100	20	21100	17	28600	18	23600	14	28000	18	40000	7.6	40200	32	12300	19	23400	2.6	71000	25	10700
28	16	21800	18	21900	7.8	41900	18	33000	17	27700	14	27200	18	84600	8.5	39300	26	17400	16	25100	2.0	69000	23	14500
29	15	25400	19	25500	12	31700	18	26300	--	--	12	30000	17	69600	18	32800	24	22700	16	29500	3.2	68000	25	14200
30	15	28100	20	25200	14	27100	19	26900	--	--	14	32900	15	24800	170	12600	19	20700	12	36000	3.9	66600	24	14400
31	17	30000	--	--	16	29400	19	25600	--	--	12	33400	--	--	56	7780	--	--	9.2	36000	5.2	66800	--	--
	20.6	23100	18.2	24600	16.4	24800	18.8	25100	17.7	24200	16.1	27500	100.4	9690	64.1	17900	36.7	17800	117.7	8220	7.1	39400	116.8	11200

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 4

Location : **Elm Fork of North Fork of Red River near Reed, Okla.**

Water Year : 1965

Basin : **Red River**

Tributary to: **Red River**

Remarks :

Equations Used to Comput: Constituents

Chlorides: Log Cl = 1.29117 Log Sp. C. - 1.74855

Sulfates : Log SO_4 = 0.35335 Log Sp. C. + 1.79713

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1															6.7	35100	3.2	37000	28	16700	2.9	42000	5.3	37500
2															6.2	36000	103	37800	23	17900	2.5	44300	3.6	40300
3															6.2	38000	119	2660	19	19900	2	46300	2.2	44500
4															6.2	40100	4920	3090	16	21000	1.6	47400	2	49900
5															6.2	40500	1890	2640	17	22000	1.3	49400	6	41000
6															208	33500	335	3270	16	22900	1.4	40600	800	6370
7															227	2990	151	6060	14	23200	2.5	20700	100	15000
8															41	4330	94	8240	13	23100	6	37600	60	16000
9															22	6730	56	10500	11	24100	5	45500	35	21900
10															33	7360	42	12100	10	26300	3	47100	25	27500
11															30	20700	41	14000	8.7	28300	2.5	47200	20	32800
12															19	31200	41	14700	7.7	30000	1.8	49400	18	38300
13															17	37600	276	13500	6.7	30800	1.3	52100	17	40500
14															23	26500	271	3780	6.7	32100	1.6	52500	16	44000
15															14	30900	285	4730	7.7	32800	2.2	48000	15	45200
16															12	37000	555	5000	6.7	33200	2.2	48200	14	45600
17															11	39000	128	4920	6.7	34700	3.5	49100	12	47800
18															9.7	39500	81	6810	5.8	35100	4.5	53300	20	35900
19															9	37700	58	9720	4.0	36900	4	58600	200	9800
20															82	40500	54	11100	2.9	40000	7	60000	700	4340
21													11	26600	6.2	44000	34	12800	2.5	40700	5	60000	1360	3790
22													10	28000	5.8	44100	30	14300	2.2	40600	4	60000	134	4220
23													9	29400	4.8	40600	184	7270	1.8	41400	3	60000	60	8520
24													8	29700	5.8	41600	128	6630	1.6	42200	2.5	59400	34	14000
25													7	27700	4.4	45000	961	19000	1.3	42100	5	25400	31	16900
26													12	29900	4.0	47800	401	6180	1.3	43900	10	31800	28	19600
27													10	32600	17	44800	105	6600	1.6	42900	4	40300	24	23000
28													10	36600	13	24600	56	7830	25	26100	3	44900	20	25200
29													9.2	37700	8.2	27500	45	11400	14	35600	10	18700	17	27900
30													8.2	35000	4.8	31400	36	14300	6.2	38500	25	22500	14	30400
31													--	--	3.6	32800	--	--	4.0	40300	7.2	32500	--	--
Mean													--	--	25.6	21600	383	5810	9.42	26100	4.44	39300	126	7880

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 4

Location : Elm Fork of North Fork of Red River near Reed, Oklahoma

Water Year : 1966

Basin : Red River

Tributary to: Red River

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.28233 Log Sp. C. - 1.68305

Sulfates : SO_4 = 0.0281 Sp.C. +1146

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	13	31000	33	18400	23	22000	27	22200	22	27800	22	22900	20	26500	18	25500	5.4	43500	3.4	34000	4.0	34000	920	4535
2	14	32000	31	19100	25	21300	26	22000	24	25500	21	23900	19	26500	19	27800	7.0	37000	2.5	37800	2.0	45000	100	7250
3	15	32100	31	20300	25	20200	24	22000	26	23400	19	23800	18	26600	17	28300	6.2	37500	1.9	39900	1.3	43300	71	9590
4	17	31800	31	21000	24	21600	22	22000	28	21700	16	23300	18	28300	15	29000	3.8	41800	1.5	42000	1.0	45600	846	4060
5	23	31000	31	20200	23	21000	22	21500	34	19400	16	22800	17	29700	14	29000	3.2	43300	1.3	44900	.9	46700	110	[illegible]
6	21	31000	31	20700	24	22300	23	20000	36	18000	15	23600	16	28900	13	29000	2.5	44000	.8	50300	1.3	49100	50	5090
7	20	32300	31	21000	24	23700	23	21100	35	16100	15	24000	15	29000	13	29000	2.2	45600	.8	51800	1.6	45000	30	13110
8	16	32600	31	20900	23	23600	22	21800	67	10600	16	24600	15	27700	12	29000	1.9	47500	.7	53400	1.0	48300	26	15500
9	14	33300	32	21000	25	23400	21	20700	43	13000	18	23400	15	26800	11	29800	1.7	50000	.7	54800	2.2	49800	22	[illegible]
10	13	33800	31	21300	27	22500	20	21300	31	19600	18	23500	14	27300	12	30800	1.5	50000	1.1	50800	21	46100	20	21300
11	11	35200	30	21800	27	23100	20	22300	27	20000	21	23500	14	28600	12	30800	1.5	47300	.8	54200	18	25500	18	21000
12	9.7	36600	29	22000	26	23300	20	23200	26	20300	149	8770	14	29600	11	32600	1.3	46500	1.0	56000	6.4	29100	16	21500
13	9.7	36600	27	22000	24	23900	20	23500	25	20000	23	18400	14	29800	11	34500	1.3	45800	3.2	56300	4.4	32800	16	23500
14	11	36800	26	22300	24	22400	20	24100	24	19800	20	22000	13	29900	10	33100	1.2	47000	1.8	57800	11	42000	14	24600
15	13	36800	26	22700	23	21900	20	24100	24	19500	19	23700	13	29000	9.9	31500	1.3	47000	1.3	57300	9.4	32900	58	19900
16	13	37600	23	22300	24	22100	20	24000	24	20600	19	24500	12	28500	9.9	32600	1.2	47500	.9	58000	2.5	34125	62	14700
17	413	30400	22	21700	24	22700	20	24400	24	22400	19	24500	11	29100	8.8	33100	1.4	47000	.7	58800	.5	39500	273	17300
18	6240	2300	22	21600	26	23300	19	24400	22	21600	18	24500	12	29700	8.1	34600	2.7	48300	.6	56000	6.4	35900	886	6190
19	493	3190	22	21900	26	22300	18	22200	23	20500	16	24500	12	31200	7.4	35100	4.7	50100	.5	60500	402	13980	128	6040
20	188	4930	24	21500	25	22200	15	24500	24	20000	16	24800	12	32400	7.0	35300	6.0	53900	2.6	56250	112	5590	64	9280
21	127	6410	26	22100	25	22900	18	22700	26	20000	16	24600	12	31800	6.7	35800	5.2	57800	2.1	54000	50	8025	46	12900
22	101	7360	27	22900	25	23000	21	19800	26	20800	15	26500	22	25500	6.5	36600	5.3	56200	1.7	55750	70	11910	37	15700
23	78	9690	27	22900	33	23700	25	20000	22	22300	14	27000	38	24700	5.7	38200	13	55800	1.8	53250	337	6865	30	16900
24	63	11500	26	23100	42	23900	30	23900	21	23100	14	26900	32	30000	4.9	39200	6.7	49000	159	35000	742	2820	28	19500
25	51	13000	26	23000	33	23800	32	25900	22	21100	15	26800	26	22000	4.7	39400	4.7	46100	363	4050	105	5880	26	20600
26	44	14800	25	23000	29	23100	28	23000	22	20300	15	26700	25	22500	4.7	39200	3.4	46500	72	8425	49	11000	24	21900
27	40	15700	22	23000	27	22200	20	16700	27	20100	19	26500	21	24500	4.7	39100	3.0	47600	33	15270	37	17800	423	12900
28	38	16400	22	22900	26	21900	19	18800	27	20700	108	13800	19	27000	4.7	39800	11	51800	16	25000	32	19500	530	2910
29	36	17000	22	23000	26	21700	18	24300	--	--	28	18200	17	24400	4.9	40800	10	36100	11	33000	30	23300	125	7420
30	35	17000	22	22500	26	22000	18	26000	--	--	23	23500	18	24000	6.2	42500	5.4	32000	8.2	30000	27	25000	26	8000
31	35	18600	--	--	27	22100	20	27900	--	--	20	25500	--	--	7.0	43800	--	--	6.2	31100	731	19780	--	--
Mean	265	5430	27.0	21600	26.2	22600	21.6	22600	27.9	19400	25.3	19600	17.5	27200	9.7	32200	4.2	46800	22.6	15700	90.9	11950	168	7584

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 4

Location : **Elm Fork North Fork Red River near Reed, Oklahoma**

Water Year : **1967**

Basin : **Red River**

Tributary to: **Red River**

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.24628 Log Sp.C. -1.52955

Sulfates : Log SO_4 = 0.34493 Log Sp.C. +1.72892

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	42	9800	17	27600	20	26100	18	28000	16	25800	14	28000	15	32500	11	26400	70	8960	30	21700	9.7	24400	8.7	33900
2	31	13000	16	28000	20	27300	21	26500	16	26100	13	30000	15	33000	9.2	27200	48	12800	26	24100	9.7	26200	3.6	30000
3	28	16000	17	28000	20	26800	13	26400	16	26600	13	31800	15	33000	8.7	26900	34	15800	43	25500	9.2	27700	3.2	28000
4	24	18000	18	28000	20	26800	15	24500	16	26900	13	31500	14	31700	9.2	27300	28	19100	3770	2950	13	26700	310	15100
5	23	19300	18	27300	20	26200	18	22200	16	26000	13	30300	13	30200	314	25700	24	21300	423	3700	16	27800	187	5250
6	22	21400	19	26300	20	25300	18	22500	16	28100	13	30000	13	31300	1840	3690	22	23300	155	5300	21	31700	74	8670
7	21	21500	19	26000	20	25300	18	21800	14	29200	13	29900	12	31000	219	3540	20	24800	88	7100	14	28300	60	15300
8	21	21900	18	25800	19	27600	17	24600	15	29300	11	31100	11	30800	81	5850	15	27000	48	8100	11	27400	43	11500
9	20	22800	18	25200	19	27900	19	25900	16	26500	14	28200	12	31900	61	9180	12	29400	29	10200	9.7	29800	27	15500
10	19	23300	19	25000	16	27500	19	28200	16	24500	16	28700	12	32900	50	10600	9.0	30000	21	13000	8.7	33600	19	20100
11	19	23500	19	25500	16	27000	19	29000	17	25200	16	25700	12	32700	41	12200	6.2	31000	15	14000	8.2	34000	14	22700
12	18	23600	20	24900	19	27100	21	20400	16	25100	16	24900	1890	8480	36	13400	5.1	31800	11	16500	7.0	34000	9.7	25500
13	18	23700	20	24200	18	24700	20	20100	16	25100	16	27600	1680	4340	32	14900	4.8	32300	8.7	18700	5.2	34100	7.7	28600
14	16	25100	20	24600	18	22300	19	20400	16	24600	16	29300	263	3640	30	16100	4.4	33400	6.7	20500	4.6	35000	14	26900
15	16	25200	20	25600	18	22200	18	23000	14	26600	14	30500	128	5730	27	17800	4.0	35100	4.8	21300	3.9	36300	15	27000
16	16	25200	20	26100	20	22300	18	25000	14	29500	14	30400	92	9300	22	18100	3.6	36300	4.4	22100	3.2	34500	10	32500
17	23	25000	20	26500	19	23800	18	25800	14	28000	14	30800	72	9880	20	19700	21	34500	4.8	23100	6.7	33500	8.2	33900
18	27	25700	20	24800	19	26000	15	27500	14	27500	14	31400	61	13100	17	20200	7.2	32900	4.8	24000	9.7	34000	6.7	34200
19	25	26200	20	24400	19	26300	12	27700	15	28100	17	28700	54	14600	16	21700	4.8	30300	816	10700	9.6	35900	6.2	35100
20	21	26000	20	25000	20	26500	14	28900	14	29400	26	27200	50	16500	17	22300	4.0	33200	306	3880	5.3	38100	811	18400
21	20	26000	20	25000	20	26000	20	24000	14	29100	34	24100	46	18700	19	22600	3.2	37800	110	5040	19	27200	1110	3200
22	20	26000	20	25800	20	26000	19	24600	14	30000	24	17900	34	18300	16	24600	2.9	40300	70	6900	18	31600	238	3630
23	19	25500	20	25500	16	28100	19	23300	14	29000	[illegible]	21800	29	19800	14	26900	2.5	40300	46	9150	13	37900	74	5400
24	19	24300	20	25000	14	27700	18	25300	13	28000	18	25700	23	20200	11	27100	1.6	42400	33	11900	8.2	33600	55	8750
25	19	24100	21	24000	13	30000	16	28500	13	27300	18	27900	20	20800	8.2	27000	566	17500	25	14800	5.3	35000	45	10500
26	20	24400	21	23800	12	33700	16	28500	14	26000	19	28500	18	22900	6.7	28000	289	3630	20	17300	3.6	35300	34	12100
27	20	25400	20	25400	16	30600	16	29500	15	26000	17	26700	16	23100	6.2	29000	74	6790	17	19100	3.2	35800	64	10300
	19	25800	20	26700	20	30400	16	28200	15	26200	16	29800	15	23800	6.7	28800	48	11700	16	20400	2.9	36000	31	11300
	19	24100	19	25700	14	27800	16	29000	--	--	15	30000	15	24600	55	22900	38	14700	15	21400	1.8	37700	28	16200
	19	23400	19	25300	10	29100	16	28500	--	--	15	30000	14	25500	59	11500	34	19300	13	22100	1.3	38600	25	17400
	19	25200	--	--	14	31000	16	26000	--	--	15	30300	--	--	201	7660	--	--	10	23300	25	29200	--	--
	21.4	22200	19.3	25600	17.7	26700	17.4	25400	15	27100	16.3	27800	155.9	8230	105.3	86[illegible]	46.9	14700	199.7	5260	9.2	31100	111.4	10400

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 5

Location : **Elm Fork of North Fork of Red River near Mangum, Okla.**

Water Year : **1965**

Basin : **Red River**

Tributary to: **Red River**

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.23993 Log Sp.C. -1.52385

Sulfates : Log SO_4 = 0.29992 Log Sp.C. +1.96980

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1															8.9	30700	4.1	17600	43	11600	3.6	25800	7.0	23900
2															8.4	30300	175	15400	34	12300	2.8	27700	4.8	25800
3															7.5	28500	261	5460	30	15000	2.2	28400	3.6	27000
4															7.0	29500	5090	2180	26	15900	1.8	28000	2.6	28200
5															7.0	31100	2320	2490	26	16600	1.4	28000	163	22900
6															7.9	30900	519	3400	53	11400	2.7	27600	1530	3070
7															878	7160	193	5060	26	12500	14	20500	480	4400
8															137	4710	154	5910	19	16700	11	20700	114	6200
9															36	9000	80	7860	17	17800	6.2	21800	60	10000
10															28	13400	73	9020	14	18500	4.5	22700	41	14600
11															41	17800	61	10700	12	19600	3.3	23500	33	16400
12															25	13800	54	12500	9.8	20800	2.0	24400	28	18200
13															20	18000	251	71100	8.9	21300	1.8	24800	23	20100
14															43	21000	915	2640	8.4	22000	1.8	25600	20	21500
15													492	4060	22	22300	521	2450	7.9	22000	2.6	25100	18	22500
16													100	5060	16	23500	868	3280	7.0	22300	2.6	24200	17	23900
17													49	7720	14	25100	244	3040	6	23000	2.0	24300	16	24900
18													32	10200	12	26300	115	4890	5	23300	3.1	25400	19	20300
19													24	14200	9.8	27500	80	7130	4	23900	2.6	25900	3480	4720
20													20	17800	8.4	28100	60	9260	3.9	24600	5.0	25200	2910	1530
21													17	20100	8.4	28800	40	11100	3.6	25000	7.0	22600	4270	1620
22													15	21400	8.4	29700	35	12100	3.3	24800	4.8	14300	821	2110
23													13	22700	7.5	29900	225	10600	2.6	24700	3.9	16900	196	4190
24													12	23800	7.0	30100	246	4420	2.4	24900	2.6	21900	94	6740
25													12	24000	5.8	31000	1580	2830	2.4	24500	1.7	24500	50	9060
26													26	19000	6.2	30900	1240	2850	2.2	23900	11	34500	30	11000
27													16	16300	5.1	30800	297	4870	2.0	24900	5.5	37000	20	12700
28													13	25500	15	36100	115	5850	3.6	25900	3.6	32500	18	14900
29													12	27800	10	38800	80	7690	13	27600	4.2	30200	16	16000
30													10	29300	7.0	30100	52	9150	8.3	26900	37	32000	22	17100
31													--	--	5.1	22000	--	--	4.8	25500	12	21800	--	--
Mean													550	--	45.9	113[illegible]	532	3360	13.2	16800	5.49	26300	484	3400

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 5

Location : Elm Fork of North Fork Red River near Mangum, Oklahoma

Water Year : 1966

Basin : Red River

Tributary to: Red River

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.38632 Log Sp. C. - 2.12817

Sulfates : SO_4 = 0.00382 Sp.C. +1653

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	22	18300	58	14500	33	18800	32	19000	28	21750	37	16400	24	17250	24	22750	11	27700	7.9	37800	5.8	22450	1600	4360
2	22	19230	55	15100	34	18700	32	19000	30	21600	33	16900	23	19250	23	22000	10	28000	5.5	38650	4.8	23700	294	3480
3	22	20000	49	15800	35	18300	30	19500	30	[illegible]	31	18600	21	19400	23	22000	9.8	28900	3.9	36600	4.1	25000	106	5430
4	24	20200	48	15850	34	18500	28	20000	32	[illegible]	27	20000	20	19800	21	22700	8.9	30100	3.6	35250	3.6	25000	573	5570
5	29	20750	47	16300	33	17800	28	20000	40	19800	24	19750	20	20400	20	23000	7	30500	2.4	34250	3.3	25750	332	4130
6	30	21100	46	17200	32	17600	28	20000	44	18600	24	19700	20	21000	18	23100	5.8	30000	2.0	33300	3.6	26000	121	4760
7	28	21530	46	17000	32	17950	27	19600	45	17500	24	19700	20	21000	17	23400	4.8	30000	1.4	33000	8.9	24000	68	8100
8	24	22300	46	17000	32	18000	27	19100	44	16700	24	19550	21	21400	15	24000	4.5	30000	1.2	33000	15	21000	50	10850
9	22	23100	46	17250	32	18000	27	19000	200	7800	27	19300	20	22500	15	24000	3.9	29500	.9	33100	6.2	14850	34	13600
10	20	23000	43	17000	33	18000	27	19000	65	4540	28	19600	20	22950	14	23800	3.6	28900	.9	32400	4.8	9330	28	14800
11	19	23000	43	17000	35	18600	27	18900	46	8850	28	19450	20	22750	14	23500	3.3	28400	.9	31900	220	7520	26	16200
12	15	23800	43	17200	36	18400	27	18200	42	14100	344	8100	20	22000	13	23850	2.8	28000	.5	31400	150	6900	24	17900
13	15	24000	37	17600	35	18100	26	18300	38	16200	126	2560	20	22000	13	24200	3.1	28000	.3	31000	28	11700	24	18900
14	14	24100	37	17900	33	18700	26	18850	36	17000	51	7530	18	22300	13	24250	2.8	28000	.2	30200	26	12100	24	19200
15	14	24200	37	17900	33	19100	26	19600	34	17250	38	12150	18	22900	13	24400	2.8	28000	.9	30000	19	13250	30	18800
16	14	25550	37	17900	33	19800	26	19600	34	16500	33	14850	17	23300	12	24800	3.3	26750	3.1	29150	17	26300	117	13700
17	22	24400	36	17500	34	20000	26	19600	32	16550	29	17500	16	24000	12	25400	3.6	26000	1.4	27900	12	32300	94	10100
18	9320	2525	36	17500	35	19600	25	19200	32	16750	28	18500	16	23800	12	25800	15	22400	.7	29150	9.8	31800	1240	4800
19	3480	1740	35	17400	35	20200	27	14950	31	17850	27	19500	16	23300	10	25900	13	15600	.3	29900	219	21200	306	3200
20	430	3600	36	17350	36	20800	32	13700	31	18100	26	20000	16	23800	10	25600	6.6	15700	.2	30000	318	4860	124	4800
21	258	5800	36	17400	36	21000	28	15350	36	15500	25	20000	16	24000	10	25650	6.6	19650	.2	28800	76	5960	80	7950
22	191	7440	36	17200	36	20900	26	18600	35	17100	24	19750	25	23900	9.8	25700	14	23400	.1	27200	64	7760	56	10700
23	156	8500	36	17500	40	19950	22	19600	35	17500	24	20200	54	23100	9.4	25800	9.8	17000	6.0	27950	212	8500	44	12750
24	126	10200	36	17900	75	16950	30	18900	33	17900	24	20950	53	23000	8.4	26100	10	21350	18	18000	1400	3000	36	14950
25	110	10950	36	18000	59	14950	40	18350	33	18500	24	21250	42	24400	8.4	26300	9.4	30000	379	11300	329	3100	30	15450
26	98	12000	34	18250	40	18100	26	19150	33	19500	24	22000	34	22700	7.9	26150	6.6	32500	135	6950	115	5300	27	16900
27	86	12450	32	19100	34	18550	30	22000	36	18100	25	21900	30	20250	7.9	26100	4.5	32500	51	9780	65	8800	128	15200
28	78	12950	31	19000	32	20300	28	20900	42	16900	85	19450	26	21500	7.9	26250	2.8	32500	25	13200	44	11000	1260	3170
29	70	14000	31	19000	31	19400	26	19900	--	--	52	6930	25	22750	7.5	26000	4.8	32600	17	15800	32	15000	247	3275
30	68	14100	31	19000	31	19100	24	19900	--	--	32	10450	24	23000	7.0	26000	12	34750	13	18750	27	16950	106	5275
31	62	14500	--	--	32	19100	26	20750	--	--	28	13150	--	--	7.5	27200	--	--	10	19200	42	17500	--	--
	481	3490	40	17200	36.2	18700	27.7	18900	42.8	15100	44.4	13500	23.8	22200	13.0	2420	6.9	26200	22.3	12400	113	[illegible]	241	5350

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 5

Location : Elm Fork North Fork Red River near Mangum, Oklahoma

Water Year : 1967

Basin : Red River

Tributary to: Red River

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.25625 Log Sp.C. -1.57209

Sulfates : Log SO_4 = 0.28303 Log Sp.C. +1.98577

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	72	8290	17	23000	18	23700	17	24300	18	26000	16	24800	15	24900	14	21200	99	7890	33	15300	16	16900	33	16900
2	52	11000	17	23300	18	23700	21	25400	18	26000	14	25700	13	26100	13	22000	118	5780	28	17500	14	17200	13	21700
3	43	12900	17	23800	18	23900	20	24500	17	24400	14	26100	13	28000	12	22900	57	8430	25	18100	13	17800	7.5	19850
4	38	14700	17	24300	19	24200	18	22300	17	24500	14	27100	13	29000	13	23500	38	12400	4400	3470	15	17800	65	19700
5	34	15300	17	24400	20	24000	21	21400	17	25000	14	28000	12	29000	20	19600	28	15000	1300	2530	23	17900	372	7200
6	31	16200	18	24300	22	24000	23	22000	15	25000	13	28000	12	28500	2520	5100	22	17200	258	3390	31	15200	137	5120
7	30	17200	20	24000	21	24000	21	21600	16	24300	13	27700	12	27700	450	3010	18	18800	144	5530	25	19600	75	7700
8	29	19000	20	23100	20	23900	14	20300	15	24100	12	26900	12	28000	143	4140	14	19500	98	6780	18	21900	73	13500
9	28	19100	20	23600	20	23100	15	21400	16	25300	13	26200	12	27800	86	6040	12	20400	66	7910	14	24000	43	13500
10	26	19900	20	23500	18	23600	18	20600	15	26100	13	27100	12	27000	62	8560	9.2	21800	46	8900	12	24000	30	13350
11	24	20700	20	23700	18	23700	21	22000	15	24900	15	27700	12	27800	48	10500	7.2	22300	30	10500	10	23800	21	15300
12	23	21000	20	23800	18	23400	25	24300	16	23600	14	26800	2110	9780	40	11500	6.3	22700	20	11600	9.8	23700	15	17600
13	22	21000	20	23900	20	22700	26	24100	16	23600	14	25900	2980	2070	35	12500	5.8	23500	15	13000	9.4	23600	13	19800
14	20	21500	20	24000	20	22800	26	21700	15	24400	13	25500	694	2780	32	13400	5.5	22800	11	13700	8.4	23100	82	9890
15	19	22000	20	23300	20	22500	24	20200	13	24000	13	26100	198	3950	29	14000	5.1	23300	8.0	14500	7.9	22400	22	13000
16	19	22000	20	23000	21	22500	23	21200	13	24000	12	26900	128	6410	27	14700	4.5	23500	6.2	15400	7.0	21700	15	16200
17	24	21100	19	23200	22	22500	20	23600	13	24000	13	27300	100	7250	24	15800	5.1	23300	5.4	15600	6.6	21700	12	19900
18	32	20300	19	24300	23	22500	17	23800	13	24800	13	27300	92	10600	20	16200	17	22400	6.0	16100	18	14900	9.8	21000
19	35	20000	19	25000	22	23000	15	23500	13	24900	16	26400	70	12900	18	17000	8.0	25900	1220	7450	11	17100	7.9	22600
20	32	21000	19	23700	24	23600	18	23800	13	24600	26	22600	55	12100	20	17800	4.5	25600	1070	3580	9.4	19500	43	25000
21	28	22600	19	23000	24	24000	22	24200	14	25000	31	22700	45	11100	22	18000	3.8	25400	248	4400	8.9	19300	1530	4380
22	24	17700	18	23000	23	23900	23	25500	14	25900	37	30100	34	13400	19	18500	3.5	25900	160	5580	15	23500	544	2680
23	20	14500	19	23800	18	24000	22	23300	13	26800	24	18500	28	17300	17	19600	3.4	25300	96	6900	17	26700	157	2940
24	18	15500	19	24000	15	24000	22	23800	14	27000	18	21600	25	17500	15	19800	3.9	25500	63	8500	13	28000	88	4930
25	19	18300	20	24000	13	24000	20	24200	14	26900	17	22400	22	17500	14	20900	119	21700	41	10000	11	28000	59	6650
26	19	21500	20	24000	20	24000	19	25200	14	25800	15	23500	23	18800	13	21600	648	6150	33	11500	7.8	28000	58	9380
27	19	22000	20	24000	24	24500	20	25900	15	25500	18	25200	21	19000	14	21900	148	3930	28	11800	6.0	28000	101	9940
28	18	22500	18	24000	18	25200	18	26000	15	24500	15	23300	20	19000	15	21000	73	6950	26	12900	5.1	28000	86	8620
29	18	23200	17	24000	15	26000	18	26100	--	--	13	24300	19	19200	17	19200	47	9880	24	13800	4.8	27800	41	8280
30	18	23400	17	24000	13	25900	19	26000	--	--	12	26000	17	20600	109	14100	36	12700	22	14400	4.1	25700	32	12000
31	17	23000	--	--	15	24200	19	26000	--	--	14	25000	--	--	131	14600	--	--	18	16200	12	24900	-	--
	27.4	17700	18.9	23800	19.4	23700	20.2	23500	14.9	25000	16.1	25400	227.3	6100	129.4	6920	52.3	9450	308	4500	12.4	21200	126.	6480

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Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490

Location : North Fork of Red River near Headrick, Oklahoma

Water Year : 1961

Basin : Red River

Tributary to: Red River

Remarks : Records poor. Stratification nil.

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.2890 Log Sp.C. -1.7093

Sulfates : SO_4 = 0.1206 Sp.C.

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	32	6127	670	3450	165	6628	396	3851	209	7089	287	3486	299	4361	150	7030	52	7500	134	4776	76	5026	44	6331
2	26	7026	357	4300	159	6643	389	3871	272	7085	184	3822	395	3967	220	3243	53	7462	113	5237	69	6109	42	6636
3	23	7500	276	4535	155	6688	397	3950	294	5830	149	5040	431	3906	192	5745	72	6622	175	4527	64	6895	55	5759
4	22	8218	258	4883	159	6600	398	4050	360	4587	138	5958	529	3417	179	5220	1145	1947	196	2962	61	6900	121	3515
5	19	9388	239	4944	167	6689	394	4249	389	3640	115	6274	493	3076	136	3915	6326	1588	100	4088	60	6626	295	3351
6	19	9676	242	4900	181	6737	424	4163	371	3432	111	6528	476	3000	108	4503	5028	1013	85	4803	71	6454	168	1875
7	16	10177	225	4879	210	6368	506	3541	372	3625	112	6751	351	2508	190	5268	4076	1246	80	5431	71	6400	106	2832
8	15	10452	199	4841	219	5700	474	3400	360	3759	103	7198	273	2597	222	3413	5808	1390	74	5478	87	6442	109	2480
9	15	10309	441	4663	213	5209	406	3583	358	3006	111	7477	326	3268	172	3197	11035	1532	84	5500	64	6953	70	4200
10	14	10608	450	4253	238	5187	275	3800	359	3142	105	7242	383	2752	164	4523	4135	1410	110	5269	59	6664	293	6000
11	12	7569	438	4251	256	4917	221	4440	367	4294	101	6900	439	4110	102	4848	2858	1762	106	5476	59	6006	153	3600
12	1465	2469	352	4323	283	4872	210	5200	395	4174	102	6851	323	2900	87	5464	2638	1937	129	6591	58	5143	119	3500
13	6196	1542	176	4759	376	4900	212	5050	538	3767	102	7149	265	4200	80	6531	2613	2056	240	5743	52	5427	225	3150
14	3213	945	166	6063	560	4184	223	4900	611	3188	106	7238	241	4600	72	6644	2830	2027	724	2270	56	5763	157	3850
15	1191	992	163	6780	689	3925	279	4540	557	2863	106	7516	224	4800	67	7319	2816	1968	227	3619	67	6437	113	4700
16	606	1526	171	6980	1062	2345	435	4200	361	2775	106	7354	220	4800	65	7789	2453	1964	127	3235	105	8440	98	5300
17	355	1847	278	5811	1164	2460	419	4100	324	3358	160	6634	190	5000	65	9346	1659	1963	98	3940	100	9638	83	6200
18	8956	997	286	4963	837	2820	404	3850	275	2566	508	4110	129	5100	119	8158	859	2291	81	4350	90	6728	74	7620
19	19025	1085	289	4972	790	2885	397	3850	262	2169	1106	2564	116	6500	374	2760	784	2572	67	5318	114	4127	69	7750
20	7426	1084	281	4906	699	2967	411	3831	285	3525	1039	3599	109	6540	820	2941	586	2745	58	5500	536	2165	68	7576
21	3044	1600	279	4991	451	3335	352	3691	302	3715	1140	2453	104	6812	815	2227	549	3150	80	5335	945	800	66	7290
22	2588	1962	275	5000	425	3713	266	4091	320	4115	975	2450	100	7099	266	2720	451	3184	680	2906	264	1079	62	7452
23	2380	2094	274	5169	396	3725	263	4859	357	4115	752	2848	97	7136	197	3672	294	3236	1216	1909	133	2453	59	7374
24	2200	2183	274	5166	385	3750	259	5008	375	4170	569	3112	94	7324	178	4234	276	3913	543	2591	97	3482	639	2556
25	1588	2162	272	5203	374	3918	250	5375	455	4214	446	3550	88	6751	137	4373	290	3839	417	4630	81	4137	2792	1312
26	3313	2130	258	5278	363	3987	240	5307	516	3354	278	4150	84	7164	94	3948	259	3671	209	5047	69	4570	663	1400
27	2919	2100	249	5102	365	4050	230	6312	491	3000	251	4725	84	7792	80	4811	351	3481	139	4270	61	5122	266	1600
28	1840	2250	164	5084	358	4118	223	5910	415	3000	233	5000	82	7327	74	5660	275	3303	126	4434	56	5632	164	2050
29	1164	2800	156	6417	366	4137	230	5250	--	--	243	4900	80	7596	70	6186	176	3634	110	4967	53	6199	153	2600
30	1049	3100	165	6991	373	3991	252	5870	--	--	269	4605	87	8155	66	6049	146	3694	104	5227	50	6686	137	3000
31	997	3250	--	--	406	4000	227	6213	--	--	274	4428	--	--	61	722	--	--	86	5220	48	6592	--	--
	2314	1515	277	4898	414	3861	325	4217	377	3731	332	3874	237	4183	181	4078	2030	1733	217	3604	122	3739	249	2661

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490

Location : North Fork of Red River near Headrick, Oklahoma

Water Year : 1962

Basin : Red River

Tributary to: Red River

Remarks : Records poor. Stratification nil.

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.2890 Log Sp.C. -1.7093

Sulfates : $SO_4 = 0.1206$ Sp.C.

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	108	3650	483	3968	106	6677	165	7412	99	7548	47	8048
2	129	4300	2820	885	107	6813	168	7665	90	7477	52	7456
3	128	4100	5660	932	112	7066	178	7669	86	7124	55	8403
4	127	4954	2681	890	121	6838	164	7425	84	7231	52	8685
5	110	6291	691	1119	132	6467	167	7622	82	7330	51	8238
6	93	6647	385	1592	138	6948	171	6863	79	7537	51	8704
7	85	6524	247	2158	135	6820	238	6385	79	8043	51	8721
8	84	6017	157	2805	141	6485	194	6916	75	6995	51	9075
9	131	4908	118	3421	139	6750	81	7204	65	7673	51	8963
10	1790	1193	102	3893	134	6758	51	7739	62	8024	51	8667
11	3073	420	90	4319	120	6819	51	8232	62	8030	50	8374
12	718	393	80	4600	105	7400	88	7509	59	8398	50	8623
13	289	782	73	4900	123	7800	116	6499	58	8375	50	8988
14	146	1641	73	5251	160	5500	115	5987	58	8272	50	8563
15	111	2453	108	5267	171	6254	112	6443	59	8250	50	9075
16	90	3573	157	5408	162	6517	119	6515	59	8175	50	9022
17	73	4887	421	4724	164	7017	135	6209	59	817[illegible]	48	9016
18	61	5399	344	5298	171	7203	156	6357	61	8095	47	8817
19	58	5566	196	4033	181	7443	96	6999	59	7551	48	9072
20	54	5749	149	4338	182	7921	70	8180	59	7525	55	8515
21	55	5966	125	5169	180	7619	62	8618	59	8256	51	8865
22	51	5911	110	5432	168	7249	68	8417	58	8500	50	8953
23	45	5775	104	5648	162	7300	89	8171	58	8500	50	8643
24	45	5967	109	6003	169	7112	113	7357	56	8500	47	8675
25	45	6188	95	5849	170	6629	138	6545	56	8500	45	8400
26	47	6636	82	6289	167	7071	158	6677	58	8625	44	8623
27	44	7076	82	6482	164	7275	135	7683	55	9021	43	8827
28	48	6986	78	6500	166	7357	121	8625	49	8339	42	9232
29	40	6707	92	6595	175	7362	120	8976	--	--	40	8976
30	47	6586	101	6334	171	7046	115	8431	--	--	40	9350
31	96	5701	--	--	167	7356	106	8203	--	--	40	8763
	259	1835	534	1826	150	7012	125	7279	66	7931	49	8710

Day	April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	40	8925	370	3638	293	2207	122	4250	107	5227	18	8099
2	40	9000	255	4323	1467	1797	100	4440	2466	3768	19	7494
3	39	8925	195	5019	1808	1000	83	5216	2424	1857	21	7165
4	40	8900	158	5565	662	2215	72	5792	819	1558	23	7499
5	43	8931	121	6169	386	3205	[illegible]	5302	384	1897	31	7221
6	48	8700	110	6833	339	2541	56	5594	243	2705	41	7388
7	53	8876	103	7632	2834	1218	48	5676	175	3480	50	6792
8	54	9077	97	8183	2485	1611	45	5907	131	4184	42	5959
9	56	10357	88	8651	2459	1676	50	6392	100	4610	35	6369
10	59	10125	77	8564	10335	1476	50	6405	92	5581	201	4634
11	58	10464	71	8352	7038	1078	42	7048	83	5812	202	1851
12	109	[illegible]	65	8997	5063	1461	40	6992	74	5860	83	3029
13	99	5638	57	9375	3875	1663	36	7416	65	5747	62	6425
14	80	6170	55	9651	4625	1340	50	7051	61	6879	44	9447
15	71	7643	51	9974	3750	1830	115	6857	56	7198	43	10207
16	66	8545	50	10117	4000	1837	79	10184	48	6946	38	8963
17	64	8187	48	10000	4250	1605	64	8606	43	6735	227	4409
18	62	8596	44	9825	2940	1884	133	5858	38	7050	2356	1254
19	61	7843	43	9496	226	1931	127	3006	34	7648	2125	3504
20	59	8906	45	8490	2835	1811	87	4926	40	8019	619	2279
21	56	8969	60	7893	2889	1975	79	6445	42	8684	3886	2222
22	51	8576	48	9822	2679	2089	54	6078	35	9147	2816	1361
23	50	9118	40	11557	1928	2184	51	6266	30	10251	943	1245
24	61	8599	200	7824	1080	2327	59	5521	27	9601	439	1862
25	70	8423	195	[illegible]	755	2390	289	3909	25	9399	340	2326
26	65	8049	75	[illegible]	520	2552	2091	3628	23	8399	245	2886
27	811	6382	381	[illegible]	284	2499	1075	2991	23	8061	182	3299
28	3930	3395	2001	[illegible]	248	2791	392	1786	21	8607	150	3797
29	1403	2530	799	[illegible]	189	3421	218	1873	20	9052	122	4667
30	679	3463	669	[illegible]	151	4055	146	3246	19	8527	97	5073
31	--	--	259	[illegible]	--	--	114	4192	18	8340	--	--
	279	4474	220	3938	2482	1653	194	3986	250	3252	517	2329

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490
Location: North Fork of Red River near
Headrick, Oklahoma
Water Year: 1963

Basin: Red River
Tributary to: Red River
Remarks:

Equations Used to Compute Constituents:
Chlorides: Log Cl = 1.24811 Log Sp.C. - 1.53141
Sulfates: $SO_4 = 0.08942$ Sp.C. + 322

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho	cfs	µmho
1	78	6200	112	5300	115	7700	75	8500	96	7700	178	5400	257	3000	36	11000	2140	1900	20	6700	0.1	8500	17	3850
2	68	5700	89	6300	109	6500	80	8600	112	7800	182	5300	114	2500	34	11000	3000	1900	18	7000	0	--	9.6	4800
3	66	5650	78	6700	104	6100	80	8800	99	8300	182	5200	72	4000	33	10500	2120	1200	16	7200	0	--	5.9	6100
4	59	5500	74	7200	106	6200	82	9000	82	8700	164	5100	62	7800	31	10000	662	1300	15	7200	0	--	3.8	7000
5	76	5200	70	7400	115	6200	80	8600	86	9300	165	5200	64	8600	468	1950	737	2800	14	7100	0	--	3.6	8000
6	82	4900	70	7800	127	7400	75	8200	82	9300	445	4200	72	9500	214	3200	541	2800	12	7000	0	--	3.1	8500
7	80	5500	62	8100	104	7200	74	8300	72	9000	319	3100	68	9100	62	5200	2880	1210	12	7000	0	--	0	--
8	114	5100	59	8100	84	7300	80	8400	68	8400	194	3600	59	9500	39	7000	1930	1650	13	7000	0	--	0	--
9	140	6700	59	8200	74	7700	78	8500	68	8100	186	4500	58	9900	33	9000	726	1850	13	7000	0	--	0	--
10	99	7100	59	8400	74	7800	72	8100	78	7400	190	4250	58	9500	27	9500	1360	1500	17	7000	0	--	0	--
11	82	6200	59	8600	68	7900	68	8100	86	6900	210	4250	54	10200	26	9700	1130	1400	14	7000	0	--	0	--
12	72	6050	56	8800	64	8000	60	8900	109	6500	202	4550	51	10100	23	10000	600	1950	10	7000	0	--	0	--
13	66	6300	54	9000	68	8000	50	9400	145	5500	186	5150	50	10000	21	10500	364	2600	13	7100	0	--	0	--
14	62	6700	56	9000	68	7800	40	9700	236	4400	198	4900	48	10000	20	10500	389	2800	16	7200	0	--	50	5000
15	56	7100	53	9000	62	7800	38	8300	236	3400	214	4500	45	9900	18	10700	363	3200	127	2400	0	--	24	4000
16	51	7600	51	9000	61	8400	34	7500	250	3150	198	4350	42	9900	16	10600	266	4300	50	1500	1.8	9000	95	2600
17	50	8300	58	9000	61	8400	30	7000	277	3350	190	4350	40	9800	15	10000	152	2850	43	4600	17	6800	312	2690
18	58	8100	66	9000	62	8600	26	7000	282	3500	194	4550	38	9800	14	10000	115	3000	35	10200	23	5000	656	3630
19	62	8000	72	9050	62	8600	20	8000	286	4000	178	4450	33	9900	14	10000	92	3500	20	6800	27	6900	265	6580
20	74	6700	72	9050	62	8600	15	8300	326	4100	107	4700	32	10000	22	10000	84	4500	14	6500	20	7000	104	5200
21	609	2560	76	8900	62	8500	14	8000	415	3350	80	5100	31	10000	21	10000	78	5400	11	6700	15	7000	59	5200
22	518	1600	76	8900	61	8400	13	6500	328	3400	70	6700	30	10200	20	10300	70	5300	8.6	7300	10	7000	42	5400
23	324	6300	70	8900	61	8300	12	7500	220	3950	62	7400	28	10300	19	10600	54	5200	7.2	7700	0	--	32	5700
24	148	5000	64	8800	64	8200	12	8200	182	4900	58	7800	28	10400	18	10300	237	3000	7	8100	0	--	24	6300
25	99	5200	64	8800	70	8100	13	8700	170	5500	53	7900	29	10500	17	9600	194	1100	6	8400	0	--	21	7100
26	80	5350	70	8800	68	8100	14	8700	174	5400	50	8100	37	10500	16	9200	48	2400	5	8800	0	--	19	7500
27	62	5450	76	8700	64	8000	14	8500	174	5300	50	8100	48	10600	15	9200	30	4900	4	9000	0	--	16	7600
28	445	2580	84	8700	70	8000	14	8300	170	5400	54	8800	45	10800	16	9200	26	5800	3	9000	0	--	12	8000
29	869	930	133	8000	70	8000	20	8000	--	--	50	8000	45	10800	15	9000	23	6200	2	8900	0	--	9	8400
30	239	1740	175	6500	68	8100	30	8100	--	--	72	7000	40	11000	134	8000	21	6500	1	8800	6.2	3200	6	8800
31	146	3600	--	--	74	8200	50	8000	--	--	102	6000	--	--	4270	1080	--	--	.5	8700	17	4800	--	--
Mean	162	3740	74	8070	77	7660	44	8400	175	4920	154	4880	56	8040	185	2320	681	1860	17.7	5530	4.4	6190	59.6	4380

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490
Location: North Fork Red River Near Headrick, Oklahoma
Water Year: 1964

Basin: Red River
Tributary to: Red River
Remarks:

Equations Used to Compute Constituents:
Chlorides: $\log Cl = 1.19320 \log SC - 1.29717$
Sulfates: $\log SO_4 = 0.80788 \log SC - 0.18556$

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (umho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	5	9000	12	8300	20	10200	20	15200	21	13000	31	12800	22	13000	7.7	13200	500	2800	35	9200	0	--	0.1	6400
2	4	9200	10	8500	18	10800	20	15800	20	13000	31	12900	21	13200	8.4	12200	184	2140	29	9000	0	--	0.1	5700
3	3	9400	9.4	8500	18	12000	18	15200	23	12500	29	12900	19	13800	11	12000	103	2940	22	8500	0	--	0.1	5400
4	3.5	9200	8.4	8500	18	12600	18	14200	185	7200	29	12500	20	15000	8.4	12700	66	4130	19	8200	0	--	0.1	5000
5	2	9000	8.0	8500	18	13500	17	14000	1270	1360	29	12800	22	15000	7.1	12200	52	6200	15	8200	0	--	0.1	5000
6	1.5	9000	7.7	8500	18	13600	17	14200	1190	1840	27	12800	18	15000	9.4	11500	50	8500	10	8400	0	--	0	--
7	1	9000	7.4	8500	17	13600	16	14200	646	1650	27	11800	16	15000	9.4	11500	40	11500	7	8700	0	--	0	--
8	0.7	9000	7.1	8500	16	13500	14	15000	265	5120	29	11800	14	15000	8.7	11000	35	10000	5	9700	0	--	0	--
9	0.5	9000	7.1	8500	16	13200	12	15700	142	4630	29	11200	13	15000	75	15500	29	11500	3.4	10700	0	--	0	--
10	0.4	9000	6.8	8400	18	13300	10	15700	104	5600	28	11700	12	14800	209	7080	24	13800	2.8	10500	0	--	0	--
11	0.3	9000	6.5	8500	18	13500	7	15500	85	6500	26	13000	11	15000	415	3000	26	11700	2.0	10800	0	--	0	--
12	0.2	9000	6.2	8500	17	13800	6	15200	71	7500	26	13300	10	16000	726	3250	25	9500	1.4	11000	0	--	0	--
13	0.1	8800	7.4	9000	14	14000	5	16000	64	8300	25	13800	10	16500	930	3870	27	8700	0.9	11000	0	--	0	--
14	0	--	7.4	10000	9	14100	5.5	16000	57	8800	25	12800	10	17500	245	3050	89	8890	0.6	10800	0	--	0	--
15	0	--	7.4	10700	11	14000	5.5	16000	55	9500	25	12800	10	17500	129	3300	3220	4270	0.4	10000	0.3	2900	0.2	9000
16	0	--	7.1	10700	12	13200	6	15200	53	10000	24	12500	9.8	17000	91	4260	1950	2280	0.2	9600	0.1	3200	0.2	9300
17	0	--	6.0	10700	10	13000	7	13500	50	10000	24	12800	9.4	16000	68	5300	707	2250	0.2	9600	0	--	0.2	8700
18	0	--	6.0	10800	7	13200	8	12000	48	10500	27	13000	9.8	15500	52	6300	789	1300	0.1	9000	47	3300	212	6700
19	0	--	20	8330	6.5	13800	9	12000	47	11000	39	12000	10	15000	41	6300	220	1750	0.1	8700	25	8650	167	9300
20	0	--	31	8800	6	13900	10	12200	45	11800	34	11800	18	16300	35	6700	109	3290	0	--	34	7020	83	8600
21	0	--	41	11000	5.5	14000	14	12500	44	12000	33	14000	20	15500	29	9200	88	4350	0	--	20	3500	109	8600
22	0	--	57	10500	5	14000	18	13400	44	11800	32	14500	14	10500	24	9500	164	5180	0	--	7.6	3800	268	3310
23	3.1	8500	65	13500	5.5	14000	17	15000	41	11000	31	15200	12	11000	20	9200	219	4420	0	--	2.7	5500	133	1930
24	305	2210	51	11500	7	14100	17	15800	40	11000	31	14800	12	12000	18	10200	109	2670	0	--	0.8	6200	72	2440
25	1470	635	56	8300	10	14000	16	16500	35	11000	28	14000	12	12500	15	10800	89	3100	0	--	0.3	6800	48	3080
26	164	890	44	12500	19	13500	16	16000	33	11000	26	13800	12	13000	13	11000	75	4300	0	--	0.6	7200	38	3750
27	59	1570	34	14000	19	14000	14	15200	31	12200	26	1300[illegible]	10	14000	11	11000	65	5500	0	--	0.6	5900	307	[illegible]960
28	35	3030	27	11000	18	13800	14	15000	32	12000	24	12800	9.0	15000	11	11000	55	6200	0	--	0.2	6300	244	1210
29	22	6700	24	9300	21	13500	14	15000	31	12200	23	13000	8.4	15200	21	9560	51	6700	0	--	0.2	6600	76	1210
30	18	8000	21	9500	21	13500	18	13400	--	--	22	12500	8.4	14500	163	5180	40	7600	0	--	0.2	6800	50	2550
31	13	8500	--	--	21	14500	2[illegible]	13000	--	--	22	12200	--	--	867	2130	--	--	0	--	0.1	6800	--	--
Mean	68	1220	20	10500	14	13300	13	14600	165	3940	28	13000	13	14600	138	4140	307	3490	5.0	8900	4.5	5330	60	4070

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490

Location : North Fork of Red River near Headrick, Oklahoma

Water Year : 1965

Basin : Red River

Tributary to: Red River

Remarks :

Equations Used to Compute Constituents

Chlorides: LOG CL = 1.34488 LOG SP.C. - 1.89235

Sulfates : LOG SO_4= 0.49847 LOG SP.C. + 1.00762

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	41	3790	15	12300	42	8370	35	13000	22	12000	24	12100	21	12800	29	10700	30	8010	123	2750	4.3	11000	.3	9880
2	30	6130	12	12500	42	9320	33	12900	20	12600	22	13100	23	12400	27	10400	28	9570	92	3450	4.3	11400	.2	10000
3	23	7530	22	10700	41	9350	31	13000	26	12200	24	13200	43	11400	25	9630	237	7000	76	4380	4.8	11800	.3	10000
4	17	8090	46	5090	34	8210	32	13000	27	12200	22	13400	34	12400	24	8730	579	2160	64	5100	3.9	11300	.3	10000
5	12	8280	57	8470	32	9170	32	12700	28	13100	21	13500	34	12900	23	8830	4400	2880	51	6550	2.8	9740	.2	10000
6	9.4	8000	471	5460	35	9650	34	12300	27	12100	21	13300	32	13000	23	9170	3510	2390	51	8010	2.7	10500	.2	11200
7	7.4	7820	478	1580	37	10600	34	11900	27	12300	20	13200	30	13600	22	9640	1570	2120	48	8300	3.9	11600	392	9010
8	5.5	7890	237	3610	36	11400	33	11700	26	12000	19	14200	34	13800	697	7370	500	2230	51	8500	4.1	11400	837	4970
9	4.3	8000	125	3990	35	11100	32	11500	34	11800	20	14100	39	11600	822	1960	254	2670	51	9130	3.2	11400	241	5310
10	3.5	8150	74	5880	42	10800	32	11300	35	11800	19	13500	56	12300	248	2220	178	3350	45	9730	5.0	11300	98	4350
11	2.8	8240	50	5080	42	11000	34	11800	35	12200	21	13000	36	12000	119	2680	138	4210	37	9750	3.4	12200	53	4660
12	3.0	7570	35	5560	40	11900	38	12100	33	12800	27	12300	29	12000	88	3760	111	5080	32	9530	2.4	10800	34	5380
13	3.0	7380	29	6630	41	12100	33	10900	32	12700	29	12500	55	9330	74	4450	406	3630	29	9670	5.9	12100	25	6310
14	2.1	8450	24	8020	45	12500	33	11200	31	12200	32	13100	72	7800	83	5460	971	2450	26	9980	13	12600	19	5450
15	1.5	8760	21	8840	50	13100	32	11400	31	12100	32	13500	66	12600	101	6720	1440	2120	29	10200	18	6340	14	4080
16	1.3	9000	39	8400	46	13000	31	11400	29	11700	34	13800	615	9340	72	6480	940	2260	23	11200	16	6220	12	3610
17	.8	8960	207	3780	20	13000	32	11500	28	13000	39	12800	371	3420	62	7630	1160	1750	21	11600	9.8	6380	9.0	3600
18	.5	9000	1070	4770	16	13000	32	11700	28	13000	37	12100	158	3170	52	9880	595	2650	19	11500	7.1	7480	8.7	3770
19	.2	9220	1200	1980	32	12700	33	12500	27	13400	33	12200	99	3880	113	7750	162	2600	16	11400	4.8	8480	1850	2370
20	.2	9490	612	2030	36	11100	31	13000	27	13500	32	12500	76	4880	101	4070	92	3000	14	12000	4.1	9300	14000	769
21	.2	9530	284	1810	46	11000	32	12900	26	12900	29	12600	58	6100	84	4660	64	3850	13	11900	3.0	10100	14200	573
22	.2	9430	155	2360	46	11600	33	12700	26	12800	29	12300	46	7390	50	5710	57	4730	12	11600	2.4	10800	12000	803
23	.2	9340	117	3260	42	12000	32	12400	20	12000	26	12900	39	8330	40	7100	53	5280	10	11200	2.1	10700	3850	795
24	.2	9010	90	4480	41	12500	31	12400	10	12100	23	13000	35	8980	37	8020	47	5730	9.4	11100	1.5	10100	884	1600
25	.2	10000	71	5550	41	13000	30	12200	14	13500	23	13300	35	9550	36	9080	189	5840	11	10600	1.1	9880	487	2790
26	.2	9940	60	6330	39	13000	29	12300	30	12300	22	13000	33	9910	41	8850	705	2910	16	8480	1.0	9450	354	3850
27	.1	9520	57	7240	37	13000	29	12900	26	11200	22	13000	32	10100	40	[illegible]	1520	1730	11	11400	.9	9400	280	4950
28	3.4	9990	50	7500	38	13000	28	12300	27	13700	22	13000	33	10200	64	[illegible]	716	1670	10	11100	1.2	9880	234	5680
29	37	17300	47	8000	38	13000	26	12000	--	--	21	13200	36	10200	69	[illegible]	248	2180	8.7	10900	1.3	9680	200	6330
30	27	15100	42	7420	35	13100	26	12000	--	--	21	13100	33	11100	40	5930	168	2250	6.2	11000	.6	9080	168	6550
31	19	12400	--	--	34	13000	26	12000	--	--	21	12900	--	--	32	7200	--	--	5.2	11000	.3	8710	--	--
Mean	8.26	9540	193	3650	38.1	11600	31.6	12200	26.9	12500	25.4	13000	76.8	8110	108	[illegible]	702	2550	32.6	7500	4.48	9380	1675	1100

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490

Location : North Fork of Red River near Headrick, Oklahoma

Water Year : 1966

Basin : Red River

Tributary to: Red River

Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.18015 Log Sp. C. - 1.25483

Sulfates : $SO_4 = 0.0559$ Sp.C. +454

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (µmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	149	6700	192	7780	100	10500	99	7880	60	9120	98	8530	55	11300	75	10800	19	12000	4.3	11600	2.9	10000	72	6000
2	140	6700	188	8000	106	10450	96	8330	80	9380	103	8900	55	8810	72	11000	19	12000	2.9	11900	0	--	950	4160
3	131	6950	190	7900	103	10300	92	8500	100	9830	100	8850	55	7150	92	10200	19	12000	1.4	11900	0	--	677	2000
4	122	8080	180	7600	100	10200	92	8500	100	9800	92	9000	55	7180	100	7890	16	12000	.9	12000	0	--	258	2740
5	122	9380	174	7630	98	10100	98	8930	147	9680	86	9000	55	7500	63	9200	13	12000	.6	12000	0	--	210	2980
6	122	9500	170	7700	96	10000	91	8730	138	9730	80	9000	55	7730	57	10600	9.4	12750	.3	12200	0	--	570	2110
7	120	9500	168	7700	96	10000	89	8930	137	10000	80	9380	50	7800	52	12000	8.4	13000	0	--	.4	7800	278	2260
8	113	9500	160	8230	94	10000	87	9080	153	9830	84	9380	50	8380	46	11700	7.4	13000	0	--	0	--	151	2830
9	110	9500	155	8500	94	10000	89	9080	687	5480	79	8630	50	9330	38	11000	8.4	13000	0	--	0	--	99	3090
10	100	9500	151	8500	96	10000	91	9380	521	2080	80	8760	50	10300	36	11000	8.4	13000	0	--	0	--	75	3460
11	90	9880	156	8500	98	10000	89	8960	282	7390	80	8990	50	10200	44	11000	5.8	13000	2.9	11500	0	--	49	4200
12	80	10000	153	8550	92	10000	89	9100	204	6160	84	9000	50	10200	36	11000	5.0	13000	1.9	12000	0	--	33	5300
13	84	10000	144	9050	91	10000	89	9180	158	3880	561	4800	46	10400	36	11000	5.0	13000	0	--	137	9080	31	7130
14	92	10450	142	9500	91	10000	84	8960	129	4350	584	5040	46	10600	33	11200	5.8	13000	0	--	225	1590	25	9330
15	80	9930	147	9500	87	10000	84	8800	120	5180	258	2160	46	10800	31	11200	3.6	13000	0	--	64	2590	48	7620
16	74	9000	137	9500	87	10000	80	8800	122	6030	159	2540	33	11000	33	11500	4.3	12700	0	--	18	2830	46	5860
17	70	9200	128	9500	86	10000	77	9280	106	6680	123	3410	36	11000	33	11800	18	12100	0	--	9.4	3190	74	4880
18	6760	2400	126	9500	89	10000	77	9130	100	7700	93	4210	29	11200	29	11800	5.8	12000	0	--	3.6	3860	353	4950
19	17700	1250	129	9500	87	10000	91	8850	100	7900	87	4980	25	11700	29	11800	3.6	12000	0	--	1.4	5260	808	5000
20	7680	790	128	9500	86	9920	92	8500	91	7630	93	5800	21	12000	29	11850	5.	12000	0	--	0	--	828	2390
21	1670	1340	124	9500	89	9680	96	8600	87	8380	87	6580	19	12000	31	12000	5.8	11600	0	--	93	10500	306	2050
22	705	2860	120	9650	91	9530	195	9000	91	8500	75	7330	33	11300	29	12400	8.4	11500	0	--	194	8480	176	2530
23	438	4150	120	9500	108	9300	80	9130	96	8500	69	7880	57	10400	25	12250	8.4	11000	0	--	143	3930	126	3390
24	332	4980	119	9500	1100	2560	60	8890	99	8480	66	8050	75	11750	21	12000	5.8	10800	0	--	238	2830	105	4790
25	317	5600	117	9500	336	4510	80	8780	94	8650	65	8330	109	11750	21	12000	3.6	10700	0	--	1430	2080	90	6640
26	282	5980	115	9500	252	4780	50	9380	92	9130	65	8580	132	10400	23	12000	6.3	9810	0	--	902	1180	78	8290
27	258	6280	110	9680	165	4850	100	9480	94	8950	65	8950	117	10100	23	12000	48	6800	58	11500	335	1110	75	8060
28	238	6500	104	9950	146	6830	100	9550	98	8600	65	9000	93	9000	21	1200	15	9150	65	8300	188	2460	66	8250
29	222	6580	100	10380	111	7400	100	10100	--	--	60	8980	84	9080	19	1200	11	10800	23	9750	135	4190	647	5820
30	210	6900	99	10500	106	7330	50	10200	--	--	60	8800	84	9580	19	1200	7.4	11600	7.4	10000	102	5150	730	1430
31	202	7380	--	--	98	7400	50	10300	--	--	60	11600	--	--	18	120	--	--	4.3	10000	81	5930	--	--
	1252	2040	142	8840	144	6990	88.3	9000	153	6790	121	6400	57.2	9880	39.2	109	10.3	11100	5.58	9990	139	2840	268	3570

Appendix D (Cont'd)

DAILY FLOW AND CONTINUOUS RECORDED QUALITY DATA

FWPCA Station No.: 490
Location : North Fork Red River near Headrick, Oklahoma
Water Year : 1967

Basin : Red River
Tributary to: Red River
Remarks :

Equations Used to Compute Constituents

Chlorides: Log Cl = 1.35188 Log Sp.C. -1.96250

Sulfates : Log SO_4 = 0.22076 Log Sp.C. +2.15611

Discharge (cfs) and Specific Conductance, Micromhos/cm^2 (μmho)

Day	October		November		December		January		February		March		April		May		June		July		August		September	
	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho	cfs	umho
1	284	1070	23	15000	19	16100	22	17000	35	12300	23	17000	15	17400	26	9850	89	12000	13	4730	33	8530	0.6	11000
2	174	2140	23	15000	18	16300	19	17500	32	11700	22	17800	16	17000	21	10400	341	11000	1.9	6590	32	8500	0	--
3	132	5240	23	15000	18	16600	17	18000	29	14500	18	18000	17	17000	15	11200	454	5220	12	7180	27	8480	0.2	11600
4	102	6950	23	15000	19	16800	17	18000	28	14900	19	18400	16	17000	14	11200	357	3860	56	5550	27	8530	1.7	11700
5	87	7100	23	15100	21	16900	19	18000	30	14900	21	19000	12	17000	27	10600	207	5030	2960	3810	27	9030	9.8	11900
6	84	7580	26	15200	21	17000	18	17700	29	15500	20	19000	9.4	17000	76	7930	128	5200	1640	2440	26	10000	55	13000
7	72	8500	26	15500	21	17000	53	16000	27	15600	21	19000	9.7	17000	1120	6280	86	6130	690	2640	22	11500	391	12500
8	66	9880	26	15800	19	17000	25	6960	29	15000	12	19000	8.9	17000	1090	2860	57	7530	420	3050	19	11700	215	6830
9	63	10900	25	15800	24	17000	22	9760	29	15200	16	19000	12	17000	432	2790	39	8650	295	3850	22	11900	133	6300
10	52	11000	26	15800	26	17000	30	13800	28	15100	23	18300	14	17300	199	3000	34	9950	219	4840	22	12000	102	7880
11	49	11000	26	15100	29	17000	29	15000	25	15100	19	18000	12	16600	144	3600	27	10500	167	5340	17	12000	69	8680
12	46	11000	26	14900	28	17000	23	15000	25	15100	17	18000	14	15400	116	4530	22	10500	132	5930	14	12400	35	9730
13	44	11000	26	15000	25	17000	21	15000	26	16100	17	18000	2760	8430	91	5280	17	10400	106	6380	13	12700	16	11100
14	36	12800	26	15200	23	17000	21	15000	24	16500	15	17500	3970	2310	82	6080	13	10300	86	6700	11	13800	24	11100
15	31	13000	26	15100	21	17000	24	15000	23	16500	14	16300	1740	2010	63	7510	10	10100	73	7000	9.8	13400	35	11000
16	29	13000	26	15000	22	17000	23	15300	22	16500	13	16600	912	2230	47	7850	6.4	10900	57	7530	8.0	13100	212	8090
17	33	13000	26	15000	21	17000	24	14300	22	16700	10	16300	522	2840	37	8100	8.4	11400	55	8650	7.9	12900	128	3830
18	44	13000	26	15100	21	17000	16	14100	24	17000	0	--	300	3390	27	8550	37	7320	55	8480	7.8	12700	67	3700
19	41	13000	26	15600	21	16600	13	13900	24	17000	0.3	15500	252	4080	17	9080	24	9600	63	7750	8.2	12400	34	5580
20	35	13000	26	16000	19	16400	21	12900	22	17000	5.6	16500	213	4800	16	9780	21	12200	389	7970	13	13000	19	9030
21	32	13000	26	16000	20	16100	22	12200	22	17000	9.6	17600	182	5380	16	10400	6.4	12100	1640	3750	5.3	14200	11	10100
22	33	13500	26	16000	20	15700	24	11800	21	17000	16	16600	154	5780	15	11000	1.9	12200	643	3580	6.0	14100	708	9560
23	29	14000	26	16000	17	15000	23	14100	22	17000	24	15900	126	6630	13	11000	0.3	11800	334	3050	4.4	13900	947	2910
24	29	14100	26	16000	14	15300	26	14700	23	17000	27	15100	96	8150	8.5	11000	0	--	210	3780	2.6	13400	437	2230
25	26	14100	26	16000	12	15000	26	14700	22	17000	30	15900	90	8300	4.6	11300	0	--	139	4480	2.5	13300	203	2700
26	26	14000	26	16000	11	15000	25	14500	21	17300	27	16700	69	8200	2.7	11900	6.1	9740	94	5280	15	13000	118	3460
27	25	14000	25	16000	13	15000	24	14600	22	17000	24	19400	57	8330	1.7	12000	602	8350	68	5930	26	12200	270	3190
28	23	14200	21	16000	15	15900	25	14500	23	16800	7.5	19300	47	8780	1.1	12100	434	4950	56	6480	9.5	11700	235	2630
29	23	14500	21	16000	15	15900	23	14300	--	--	5.1	18700	46	9180	3.4	12500	172	3580	62	6750	3.0	11000	384	2160
30	23	14500	21	16000	12	15900	24	14000	--	--	6.9	18600	35	9400	6	12600	58	3750	53	7500	0.9	11500	198	3580
31	23	14800	--	--	22	16300	31	13700	--	--	13	17600	--	--	29	12000	--	--	38	8130	0.9	9780	--	--
	58	8190	24.9	15500	19.6	16500	23.5	14500	25.3	15700	16.5	17600	390.9	4400	140.7	510	116.4	6730	349.3	3950	14.3	11030	174.4	5540

Appendix E

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

The tabulation presented in Appendix E summarizes the streamflow and specific conductance data of Appendix D, and lists the monthly chloride and sulfate concentrations and loads at Stations 754, 753, 4, 5 and 490.

Correlations between conductance and concentration of chlorides and sulfates were determined for each station from analyses of weekly grab samples collected during the study. These individual correlations were used to compute constituent concentrations. The correlation equations are shown for each tabulation. Flow measurements were then used to translate concentration in mg/l to load in tons per day.

Also presented as part of this tabulation is a summary of stream flow data consisting of mean annual flow and the range of annual flows in cubic feet per second.

All tabulations indicate zero when the measurement was zero and a dash when no data was obtained.

All flow data included in this compilation were furnished by the District Office of the Surface Water Branch of the U. S. Geological Survey in Oklahoma. The maximum and minimum of the daily means are shown for each month and for the entire year. Complete flow measurements are shown in this part including periods when no specific conductance was measured.

Specific conductance was flow-weighted to obtain monthly means. The concentration of each constituent was computed from the specific conductance, using correlation equations derived from laboratory analyses of weekly samples. The tabulation shows the highest and lowest of the daily means of specific conductance recorded and concentration computed during each month and the water year. A zero daily mean concentration (and load) representing a zero daily flow was not considered in selection of the monthly and annual minimum daily means. Zero daily flows are shown, however.

When continuous specific conductance measurements were not obtained for a significant portion of time, an engineering review was made of the nonmeasured periods and reasonable quality estimates assigned to all or a portion of the missing record. Flow rates, flow patterns, continuous recorded qualities before and after the no record period, similarity of flows and patterns to measured periods, and results of grab samples were used to select reasonable estimates of quality for periods up to several weeks.

Appendix E (cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: Red FWPCA Station Number: 754 Remarks:

Stream and Location: Elm Fork of North Fork of Red River at Salton Crossing, Oklahoma
Lat. 35°02', long. 99°56', NE¼ SW¼, Sec.3, T.6 N., R.26W., approximately
2½ miles above State Hwy 30 at Salton Crossing, Harmon County, Okla.
(USGS Gaging Station No. 3034.00 located approximately 2½ miles downstream from quality station.)

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
			Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
	Apr.																			
	May																			
	June																			
1960	July	22.8	50	544	10	5990	18000	2320	1350	6730	253	106	213	19	1460	2280	1010	115	367	55
	Aug.	31.0	32	442	10	8700	24800	2360	2610	11700	273	226	1420	61	1710	2590	1020	148	1690	55
	Sept.	19.8	27	189	11	8900	15500	5580	2260	5120	1020	82	169	45	1720	2150	1430	62	90	47
SUMMARY		74.0	36	544	10	7910	24800	2320	2130	11700	253	150	1420	19	1630	2590	1010	114	1690	47
1960	Oct.	31.0	192	1700	14	2580	7060	1650	301	1480	148	155	779	49	1050	1570	877	541	4160	58
	Nov.	30.0	62	73	45	4700	5500	4310	776	996	678	128	149	111	1330	1430	1290	220	252	168
	Dec.	31.0	47	63	41	4890	5800	3980	825	1080	597	105	139	87	1350	1460	1250	173	216	149
1961	Jan.	31.0	38	47	30	4980	6220	4390	851	1210	697	87	102	57	1360	1490	1300	139	168	106
	Feb.	28.0	33	42	28	5210	5800	4500	914	1080	726	82	107	58	1390	1460	1310	124	151	103
	Mar.	31.0	46	88	28	4820	6240	3220	808	1220	427	101	169	75	1340	1490	1150	167	273	109
	Apr.	30.0	52	72	41	5170	6110	4400	903	1190	700	126	166	115	1380	1480	1300	193	251	162
	May	31.0	31	49	22	6350	9060	4030	1250	2200	608	104	202	53	1500	1730	1250	124	183	95
	June	30.0	65	706	15	3860	10500	2480	570	2780	283	100	539	64	1230	1840	1030	215	1960	72
	July	31.0	24	291	8	4990	17100	2500	854	6000	286	56	224	14	1360	2230	1040	89	812	35
	Aug.	31.0	11	16	9	8670	11100	5070	2050	3030	876	60	76	39	1700	1880	1370	49	57	45
	Sept.	30.0	11	13	9	9020	15800	7120	2180	5300	1500	65	[illegible]	48	1730	2160	1570	51	58	47
SUMMARY		365.0	51	1700	8	4280	17100	1650	669	6000	148	92	[illegible]	14	1280	2230	877	177	4160	35

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: Red FWPCA Station Number: 754 Remarks:

Stream and Location: **Elm Fork of North Fork of Red River at Salton Crossing, Oklahoma**
Lat. 35°02', long. 99°56', NE¼ SW¼, Sec.3, T.6 N., R.26W., approximately
2½ miles above State Hwy 30 at Salton Crossing, Harmon County, Okla.
(USGS Gaging Station No. 3034.00 located approximately 2½ miles downstream from quality station.)

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
			Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1961	Oct.	31.0	13	17	12	7930	11200	6310	1780	3070	1250	60	99	47	1640	1880	1500	55	79	52
	Nov.	30.0	21	60	16	6490	7790	4500	1270	1730	726	73	132	52	1510	1640	1310	87	211	66
	Dec.	31.0	16	21	11	6660	10800	4870	1350	2900	823	59	147	29	1530	1860	1350	67	96	39
1962	Jan.	31.0	19	28	14	5860	10450	3670	1100	2760	526	55	127	25	1450	1830	1220	73	114	55
	Feb.	28.0	15	17	12	7250	12000	6000	1540	3430	1140	64	132	43	1580	1930	1470	66	83	55
	Mar.	31.0	15	19	13	7070	8580	5800	1490	2020	1080	60	85	53	1570	1690	1460	63	83	58
	Apr.	30.0	195	4470	13	2690	7630	1900	322	1670	185	169	2530	57	1070	1620	930	560	11580	56
	May	31.0	21	60	7	7890	9800	6880	1760	2490	1420	98	231	41	1640	1780	1560	91	252	32
	June	30.0	125	2640	8	3280	10200	2270	439	2650	247	147	1740	38	1150	1810	1000	387	7090	36
	July	31.0	42	612	6	4630	22000	2130	760	9950	222	86	366	69	1320	2460	970	150	1600	34
	Aug.	31.0	101	2470	6	2520	17500	1630	290	6230	146	79	969	25	1040	2250	875	281	5830	36
	Sept.	30.0	105	1610	6	2660	17000	1890	315	5950	185	89	804	40	1060	2220	925	300	4010	37
SUMMARY		365.0	57	4470	6	3640	22000	1630	520	8950	146	80	2530	25	1200	2460	875	185	11580	32
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
	Apr.																			
	May																			
	June																			
	July																			
	Aug.																			
	Sept.																			
SUMMARY																				

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: Red FWPCA Station Number: 753 Remarks:

Stream and Location: Elm Fork of North Fork of Red River near Carl, Oklahoma,
Lat. 35°00'35", long. 99°54'20", NW¼, Sec. 12, T.6 N.,
R.26 W., at bridge on State Hwy 30, 4 mi. NE of Carl,
Harmon County, Oklahoma.

		Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
Year	Month		Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
	Apr.																			
	May																			
	June																			
1960	July	20	50	544	10	13200	50200	5530	4100	20800	1240	673	3180	256	1500	2180	1170	246	1910	57
	Aug.	25.7	32	442	10	38600	70000	22500	14900	31300	7360	1360	15000	326	2020	2390	1740	184	2340	56
	Sept.	27.2	27	189	11	20400	43200	6530	6900	16900	1550	513	4530	238	1690	2080	1230	126	904	54
SUMMARY		73.0	36	544	10	22900	70000	5530	8140	31300	1240	855	15000	238	1750	2390	1170	184	2340	69
1960	Oct.	31.0	192	1700	14	4230	33000	1450	873	12020	217	451	2000	50	1080	1930	797	559	4240	182
	Nov.	30.0	63	74	45	10730	12880	9560	2860	3620	2470	483	619	403	1410	1480	1360	237	276	177
	Dec.	31.0	47	63	41	12510	20000	9000	3490	6340	2290	445	925	315	1470	1670	1340	187	244	157
1961	Jan.	31.0	38	47	30	15220	39700	9920	4480	15210	2590	455	1300	233	1550	2030	1380	158	174	127
	Feb.	28.0	33	42	28	13600	20130	8880	3880	6390	2250	346	633	196	1500	1680	1330	134	166	116
	Mar.	31.0	46	88	28	9430	15910	1850	2430	4740	304	302	536	72	1360	1570	858	169	266	116
	Apr.	30.0	52	72	41	11870	20000	8650	3260	6340	2180	456	820	306	1450	1670	1320	202	259	162
	May	31.0	31	49	22	15040	18980	10940	4410	5940	2940	366	660	264	1550	1650	1420	128	195	96
	June	30.0	65	706	15	7790	18390	1870	1900	5700	308	333	1860	99	1280	1640	860	225	2120	66
	July	31.0	24	291	8	11990	26560	4050	3300	9110	826	216	649	133	1450	1810	1070	95	839	41
	Aug.	31.0	11	16	9	29000	43730	14450	10190	17220	4190	297	[illegible]	176	1860	2090	1530	54	64	47
	Sept.	30.0	11	13	9	35640	56890	24330	13260	24080	8140	393	[illegible]	240	1970	2250	1770	58	67	50
SUMMARY		365.0	51	1700	8	9920	56890	1450	2590	24080	217	358	20[illegible]	50	1380	2250	797	190	4240	41

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 753 Remarks:

Stream and Location: **Elm Fork of North Fork of Red River near Carl, Oklahoma,**
Lat. 35°00'35", long. 99°54'20", NW¼, Sec. 12, T.6 N.,
R.26 W., at bridge on State Hwy 30, 4 mi. NE of Carl,
Harmon County, Oklahoma.

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO_4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
			Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1961	Oct.	31.0	13	17	12	25310	32650	15310	8570	11830	4510	289	416	157	1790	1920	1550	60	84	55
	Nov.	30.0	21	60	16	18140	25760	7460	5600	8760	1800	323	430	222	1630	1800	1270	94	205	74
	Dec.	31.0	16	21	11	19670	30000	13870	6210	10640	3860	274	419	125	1670	1880	1500	74	93	44
1962	Jan.	31.0	19	28	14	20130	40000	9340	6400	15360	2400	320	705	138	1680	2030	1350	84	130	62
	Feb.	28.0	15	17	12	20430	32000	13580	6520	11560	3870	270	527	146	1680	1910	1500	70	87	57
	Mar.	31.0	15	19	13	22920	33000	17300	7550	12030	5270	305	435	228	1740	1930	1610	70	89	59
	Apr.	30.0	195	4470	13	4220	27070	2250	870	9330	392	457	4710	236	1080	1820	910	568	10940	62
	May	31.0	21	60	7	17620	25540	12860	5400	8670	3610	300	825	137	1620	1790	1480	90	241	32
	June	30.0	125	2640	8	7270	29720	5100	1740	10510	1110	586	7910	141	1260	1870	1140	423	8140	37
	July	31.0	42	612	6	10030	46000	2700	2630	18370	493	297	1340	177	1380	2120	960	156	1760	67
	Aug.	31.0	101	2470	6	4480	35000	2350	939	12960	413	254	2750	66	1100	1960	920	298	6120	30
	Sept.	30.0	105	1610	6	5910	39500	2830	1340	15120	523	379	2430	180	1190	2030	967	337	4260	33
SUMMARY		365.0	57	4470	6	8250	46000	2250	2050	18370	392	315	7910	66	1310	2120	910	201	10940	30
1962	Oct.	31.0	26	112	18	15400	20000	10100	4730	6590	2780	334	836	258	1570	1650	1430	110	431	77
	Nov.	30.0	28	72	22	16100	20500	9000	5030	6800	2400	371	585	301	1580	1660	1400	117	281	94
	Dec.	31.0	24	41	17	16800	22800	12300	5270	7780	3570	342	508	255	1590	1700	1490	103	164	78
1963	Jan.	31.0	18	26	12	18800	45000	12000	6100	18400	3460	302	468	193	1630	1960	1480	81	112	60
	Feb.	28.0	23	29	20	16700	20000	13000	5240	6590	3820	328	495	227	1590	1650	1510	100	127	83
	Mar.	31.0	18	22	16	18700	21000	16000	6040	7010	4970	299	402	240	1630	1670	1580	81	98	70
	Apr.	30.0	16	23	11	22800	31300	17200	7780	11600	5450	328	530	253	1700	1820	1600	72	100	52
	May	31.0	41	592	6.8	9850	42000	2750	2690	16800	537	296	930	235	1420	1930	1090	157	1730	34
	June	30.0	78	527	1.4	5850	31000	2120	1390	11500	386	293	573	28	1280	1810	1030	268	1470	6.3
	July	31.0	2.4	15	0.2	47900	93000	26000	19850	46000	9180	127	597	21	1990	2290	1750	13	76	1.2
	Aug.	31.0	3.5	12	0.1	57100	16300	21300	24840	5090	7140	233	[illegible]	16	2060	1580	1670	19	66	0.6
	Sept.	30.0	26	463	2.3	12700	60000	4350	3730	26400	958	262	1190	53	1500	2080	1200	106	1490	13
SUMMARY		365.0	25	592	0.1	13800	93000	2120	4130	46000	386	281	[illegible]	16	1530	2290	1030	104	1730	0.6

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 753 Remarks:

Stream and Location: **Elm Fork of North Fork of Red River near Carl, Oklahoma**
Lat. 35°00'35", long. 99°54'20", NW¼, Sec. 12, T.6 N.,
R.26 W., at bridge on State Hwy 30, 4 mi. NE of Carl,
Harmon County, Oklahoma.

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO_4)					
			Cubic Feet/Second			Micromhos/Centimeter^2 @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
			Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1963	Oct.	31.0	8.4	16	5.3	34900	45500	30000	13600	19000	11200	308	817	187	2040	2230	1940	46	96	29
	Nov.	30.0	13	23	9	28200	38500	20200	10400	15400	6780	353	692	248	1900	2110	1710	64	120	46
	Dec.	31.0	12	20	6	26900	54000	14000	9750	23700	4250	330	671	88	1870	2360	1510	63	87	26
1964	Jan.	31.0	14	21	6	22000	42000	12000	7550	17200	3490	282	451	174	1750	2170	1440	65	100	33
	Feb.	29.0	21	53	14	20100	27200	13100	6730	9890	3910	388	792	278	1700	1880	1480	98	231	66
	Mar.	31.0	14	20	11	23700	28300	18200	8300	10400	5940	310	477	266	1800	1910	1650	67	98	54
	Apr.	30.0	10	12	6.7	30500	76000	23500	11400	36600	8210	306	1080	196	1940	2640	1790	52	78	36
	May	31.0	62	697	5.3	7490	41000	2720	1920	16700	529	319	1660	47	1230	2150	881	204	1880	28
	June	30.0	141	1550	4.7	5930	38000	3050	1430	15100	612	541	3280	191	1140	2100	915	432	3970	27
	July	31.0	2.8	10	0.2	63700	180000	32500	29200	109000	12400	218	333	47	2490	3500	1990	19	54	1.8
	Aug.	31.0	1.9	20	0.1	123000	210000	96000	67400	133000	49200	352	3800	31	3090	3690	2850	16	168	1.0
	Sept.	30.0	10	154	0.1	42300	215000	18500	17300	137000	6060	472	2510	36	2180	3720	1660	60	685	1.0
SUMMARY		366.0	26	1550	0.1	14600	215000	2720	4480	137000	529	310	3800	31	1530	3720	881	106	3970	1.0
1964	Oct.	31.0	10.6	92	3.6	45000	91000	18200	19100	45200	6270	545	1960	256	2100	2480	1700	60	439	22
	Nov.	30.0	36.4	291	7.4	13700	46000	2620	4420	19600	579	434	1320	193	1590	2110	1080	156	945	40
	Dec.	31.0	14.2	28	9	27300	44700	18500	10300	18900	6390	395	696	219	1870	2090	1700	71	137	44
1965	Jan.	31.0	12.7	15	9.8	27500	33000	22400	10400	13000	8090	356	479	243	1870	1950	1780	64	77	48
	Feb.	28.0	13.2	17	8.2	29200	68100	21600	11200	31700	7730	399	766	288	1900	2310	1770	67	88	45
	Mar.	31.0	14.9	20	13	27200	37000	22300	10300	15000	8040	412	643	357	1860	2000	1780	75	97	65
	Apr.	30.0	37	682	6	19700	39900	11500	6910	16400	3560	689	10300	177	1730	2040	1520	173	3050	32
	May	31.0	7.4	33	3.1	44600	77400	24000	18900	37100	8800	376	1010	163	2090	2380	1810	42	169	18
	June	30.0	302	3660	2.7	5070	79100	2000	1300	38100	415	1060	6980	170	1260	2400	1010	1024	9930	17
	July	31.0	8.0	24	1.4	29900	92800	17100	11500	46400	5800	249	1020	123	1910	2490	1670	41	126	8.8
	Aug.	31.0	9.3	109	1.1	73200	126000	24400	34700	67600	8980	873	13100	114	2350	2670	1820	59	723	7.1
	Sept.	30.0	84.4	644	2.7	16300	119000	3450	5470	63000	8110	1250	11300	320	1650	2640	1150	376	2960	19
SUMMARY		365.0	45.4	3660	1.1	13500	126000	2000	4350	67600	415	533	13100	114	1582	2670	1010	104	9930	7.1

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 753 Remarks:

Stream and Location: **Elm Fork of North Fork of Red River near Carl, Oklahoma**
Lat. 35°00'35", long. 99°54'20", NW¼, Sec. 12, T.6 N.,
R.26 W., at bridge on State Hwy 30, 4 mi. NE of Carl,
Harmon County, Oklahoma.

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW Cubic Feet/Second Mean	STREAM FLOW Extremes Max. Day	STREAM FLOW Extremes Min. Day	SPECIFIC CONDUCTANCE Micromhos/Centimeter² @ 25° C Wt. Mean	SPECIFIC CONDUCTANCE Extremes Max. Day	SPECIFIC CONDUCTANCE Extremes Min. Day	CHLORIDES (Cl) Milligrams/Liter Wt. Mean	CHLORIDES mg/L Extremes Max. Day	CHLORIDES mg/L Extremes Min. Day	CHLORIDES Tons/Day Wt. Mean	CHLORIDES Tons/Day Extremes Max. Day	CHLORIDES Tons/Day Extremes Min. Day	SULFATES (SO4) Milligrams/Liter Wt. Mean	SULFATES mg/L Extremes Max. Day	SULFATES mg/L Extremes Min. Day	SULFATES Tons/Day Wt. Mean	SULFATES Tons/Day Extremes Max. Day	SULFATES Tons/Day Extremes Min. Day
1965	Oct.	31.0	120	2060	9	11200	37500	2840	3830	15100	809	1240	22100	326	1530	1860	1420	493	7880	44
	Nov.	30.0	22.8	26	20	21300	25100	16600	7950	9570	5990	489	616	370	1650	1700	1590	102	117	88
	Dec.	31.0	20	31	17	21400	24000	18200	7990	9100	6650	431	668	339	1650	1690	1610	89	138	72
1966	Jan.	31.0	20.6	33	5	22700	28600	15400	8540	11100	5500	474	956	109	1670	1740	1580	93	140	22
	Feb.	28.0	19.3	29	3	20200	25700	14000	7480	9830	4940	389	698	54	1640	1710	1560	85	131	13
	Mar.	31.0	19.7	23	16	23500	27700	19500	8880	10700	7190	472	549	386	1680	1730	1630	89	103	74
	Apr.	30.0	17.9	41	14	25700	37200	17000	9830	15000	6150	474	1334	280	1710	1850	1600	82	180	65
	May	31.0	11.5	17	7.4	33900	53400	25500	13500	22500	9740	418	510	343	1810	2060	1710	56	80	39
	June	30.0	7.9	47	2	53800	122750	23900	22700	57300	9050	483	2660	278	2060	2930	1690	44	256	15
	July	31.0	32.3	734	0.2	22000	183700	3610	8240	91400	1060	717	14700	47	1660	3700	1430	145	3240	2.0
	Aug.	31.0	99.1	722	0.7	13300	157500	3900	4660	76800	1160	1240	13000	144	1550	3370	1430	415	3000	6.4
	Sept.	30.0	111	695	11	10200	26400	3215	3450	10100	931	1030	5400	245	1510	1720	1430	453	2797	50
SUMMARY		365.0	42	2060	0.2	15900	183700	2840	5700	91400	809	645	22100	47	1580	3700	1420	179	7880	2.0
1966	Oct.	31.0	20.6	31	15	23100	31300	18300	7950	11200	6120	441	840	303	1570	1710	1460	87	129	65
	Nov.	30.0	18.2	20	15	24600	28000	20700	8530	9870	7030	413	503	347	1590	1660	1520	78	87	64
	Dec.	31.0	16.4	20	7.8	24800	46000	17300	8610	17300	5740	381	470	308	1600	1910	1440	71	86	39
1967	Jan.	31.0	18.8	26	12	25100	38100	16300	8730	14000	5370	442	573	357	1600	1810	1420	81	99	58
	Feb.	28.0	17.7	20	15	24200	29000	19500	8370	10300	6570	400	528	262	1590	1670	1490	76	89	64
	Mar.	31.0	16.1	48	10	27500	33400	17200	9670	12000	5700	420	1320	283	1650	1740	1440	72	216	45
	Apr.	30.0	100.4	1630	10	9690	84600	3410	2990	34200	924	809	8140	300	1220	2280	899	329	4710	46
	May	31.0	64.1	682	7.3	17900	40200	3880	5960	14800	1070	1030	20000	249	1450	1840	933	251	2730	35
	June	30.0	36.7	647	1.6	17800	86000	6280	5930	34900	1840	586	9130	129	1450	2290	1070	144	2450	9.8
	July	31.0	117.7	2030	3.5	8220	36000	2450	2490	13100	637	789	6230	110	1160	1780	817	368	4460	16
	Aug.	31.0	7.1	29	1.9	39400	71000	23500	14500	28100	8100	277	1010	125	1830	2170	1570	35	123	10.7
	Sept.	30.0	116.8	1470	6.8	11200	67800	2750	3520	26700	725	1110	16600	302	1270	2140	850	400	5240	39
SUMMARY		365.0	45.9	2030	1.6	14500	86000	2450	4720	34900	637	584	20000	110	1370	2290	817	169	5240	9.8

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 4 Remarks:

Stream and Location: **Elm Fork of North Fork Red River near Reed, Oklahoma**
Lat. 34°58', long 99°42', on west line of Sec. 25, T.6 N., R.24 W.,
on downstream side of pier of county road bridge, 1 mi. upstream
from Deer Creek, 4.2 mi. north of Reed, and at about mile 38.

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW Cubic Feet/Second Mean	Extremes Max. Day	Extremes Min. Day	SPECIFIC CONDUCTANCE Micromhos/Centimeter² @ 25° C Wt. Mean	Extremes Max. Day	Extremes Min. Day	CHLORIDES (Cl) Milligrams/Liter Wt. Mean	Extremes Max. Day	Extremes Min. Day	Tons/Day Wt. Mean	Extremes Max. Day	Extremes Min. Day	SULFATES (SO4) Milligrams/Liter Wt. Mean	Extremes Max. Day	Extremes Min. Day	Tons/Day Wt. Mean	Extremes Max. Day	Extremes Min. Day
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
1965	Apr.	10.0	9.4	12	7	31300	37700	26600	11390	14500	9220	289	375	183	2431	2600	2290	62	77	43
	May	31.0	26	227	3.6	21600	47800	2990	7046	19700	548	486	696	11.7	2132	2820	1060	147	1400	21
	June	30.0	383	4920	3.2	5810	37800	2640	1293	14500	467	1334	7590	122	1340	2600	1010	1383	14200	22
	July	31.0	9.4	28	1.3	26100	43900	16700	8997	17600	5060	228	382	59	2279	2740	1950	58	147	9.5
	Aug.	31.0	4.4	25	1.3	39300	60000	18700	15260	26400	5850	183	501	60	2634	3060	2040	32	146	10
	Sept.	30.0	126	1360	2	7880	49900	3790	1917	20800	745	651	3150	106	1493	2870	1150	507	4220	15
SUMMARY		163.0	102	4920	1.3	7820	60000	2640	1898	26400	467	553	7590	11.7	1489	3060	1010	433	14200	9.5
1965	Oct.	31.0	265	6240	9.7	5430	37600	2300	1280	15300	424	914	7130	387	1299	2203	1210	928	20400	57
	Nov.	30.0	27	33	22	21600	23100	18400	7500	8180	6110	546	624	448	1753	1755	1660	128	150	106
	Dec.	31.0	26	42	23	22600	23900	20200	7950	8540	6880	561	967	464	1781	1816	1710	126	206	118
1966	Jan.	31.0	22	32	15	22600	27900	16700	7950	10400	5390	463	817	291	1781	1930	1610	104	161	74
	Feb.	28.0	28	67	21	19400	27800	10600	6540	10400	3000	492	617	411	1691	1927	1440	127	260	102
	Mar.	31.0	25	149	14	19600	27000	8770	6620	9990	2360	451	1230	340	1697	1905	1390	116	559	72
	Apr.	30.0	18	38	11	27200	32400	22000	10100	12600	7680	476	983	326	1910	2056	1760	90	188	58
	May	31.0	9.7	19	4.7	32200	43800	25500	12500	18600	7900	327	533	204	2050	2377	1860	54	99	28
	June	30.0	4.2	13	1.2	46800	57800	32000	20200	26500	12400	229	887	66	2461	2770	2040	28	95	8.0
	July	31.0	23	363	0.5	15700	60500	4050	4980	28100	877	303	5960	38	1587	2846	1260	97	1230	3.5
	Aug.	31.0	91	742	0.5	11950	49800	2820	3510	21900	551	860	13200	22	1482	2545	1230	363	3350	3.[illegible]
	Sept.	30.0	168	920	14	7584	24600	2910	1960	8860	574	888	36[illegible]	322	1359	1837	1230	615	3150	[illegible]
SUMMARY		365.0	59	6240	0.5	11100	60500	2300	3200	28100	424	510	13[illegible]	22	1458	2846	1210	232	20400	3.[illegible]

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 4 Remarks:

Stream and Location: **Elm Fork of North Fork Red River near Reed, Oklahoma**
Lat. 34°58', long 99°42', on west line of Sec. 25, T.6 N., R.24 W., on downstream side of pier of county road bridge, 1 mi. upstream from Deer Creek, 4.2 mi. north of Reed, and at about mile 38.

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
			Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1966	Oct.	31.0	21	42	16	22200	26200	9800	7710	9480	2780	445	639	315	1690	1790	1280	97.5	145	76
	Nov.	30.0	19	21	16	25600	28000	23800	9210	10300	8410	479	523	444	1780	1830	1730	92.4	98	79
	Dec.	31.0	18	20	10	26700	33700	22200	9710	13000	7710	463	538	291	1800	1950	1690	86	98	50
1967	Jan.	31.0	17	21	12	25400	29500	20100	9120	11000	6820	428	545	330	1770	1870	1630	83.1	102	59
	Feb.	28.0	15	17	13	27100	30000	24500	9890	11200	8720	400	436	350	1810	1880	1750	73.2	81	64
	Mar.	31.0	16	34	11	27800	31800	17900	10200	12100	5900	449	783	347	1830	1910	1570	80.3	159	56
	Apr.	30.0	156	1890	11	8230	33000	3640	2240	12600	810	939	11900	344	1200	1940	906	503	6160	56
	May	31.0	105	1840	6.2	8660	29000	3540	2390	10800	783	677	7840	180	1220	1850	898	347	4520	31
	June	30.0	47	566	1.6	14700	42400	3630	4610	17300	807	583	8740	75	1470	2110	905	185	2380	9.1
	July	31.0	200	3770	4.4	5260	25500	2950	1280	9170	624	690	6840	91	1030	1770	843	554	19900	20
	Aug.	31.0	9.2	25	1.3	31100	38600	24400	11700	15400	8680	291	735	54	1900	2050	1750	47.1	125	7.2
	Sept.	30.0	111	1110	3.2	10400	35100	3200	3000	13700	690	900	13300	89	1300	1980	867	391	26000	16
SUMMARY		365.0	61	3770	1.3	11000	42400	2950	3220	17300	624	533	13000	75	1330	2110	843	220	26000	7.2
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
	Apr.																			
	May																			
	June																			
	July																			
	Aug.																			
	Sept.																			
SUMMARY																				

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 5 Remarks:

Stream and Location: Elm Fork of North Fork Red River near Mangum, Oklahoma
Lat. 34°56', long 99°30', on east line Sec. 10, T.5 N., R.22 W.,
at bridge on U. S. Highway 283, 3 miles north of Mangum, 5 miles
downstream from Haystack Creek, and at mile 17.8.

Year	Month	Number of Days of Specific Conductance Record	STREAM FLOW Cubic Feet/Second Mean	STREAM FLOW Extremes Max. Day	STREAM FLOW Extremes Min. Day	SPECIFIC CONDUCTANCE Micromhos/Centimeter² @ 25° C Wt. Mean	SPECIFIC CONDUCTANCE Extremes Max. Day	SPECIFIC CONDUCTANCE Extremes Min. Day	CHLORIDES (Cl) Milligrams/Liter Wt. Mean	CHLORIDES Milligrams/Liter Extremes Max. Day	CHLORIDES Milligrams/Liter Extremes Min. Day	CHLORIDES Tons/Day Wt. Mean	CHLORIDES Tons/Day Extremes Max. Day	CHLORIDES Tons/Day Extremes Min. Day	SULFATES (SO₄) Milligrams/Liter Wt. Mean	SULFATES Milligrams/Liter Extremes Max. Day	SULFATES Milligrams/Liter Extremes Min. Day	SULFATES Tons/Day Wt. Mean	SULFATES Tons/Day Extremes Max. Day	SULFATES Tons/Day Extremes Min. Day
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
1965	Apr.	16.0	54	492	10	8280	29300	4060	2160	10350	892	314	1180	167	1400	2040	1130	203	1500	35
	May	31.0	46	878	5.1	11300	38800	4710	3175	14700	1070	393	4260	97	1530	2220	1180	189	3170	26
	June	30.0	532	5090	4.1	3360	71100	2180	706	31100	413	1012	21000	60	1070	2660	936	1534	12800	19
	July	31.0	13	53	2	16800	27600	11400	5190	9610	3210	185	459	16	1730	2000	1540	62	220	10
	Aug.	31.0	5.5	37	1.4	26300	37000	14300	9050	13800	4250	134	1150	37	1970	2190	1640	29	208	8
	Sept.	30.0	484	4270	2.6	3400	28200	1530	716	9670	2660	935	10100	69	1070	2020	841	1396	11100	14
SUMMARY		169.0	197	5090	1.4	4130	71100	1530	911	31100	413	484	21000	16	1130	2660	841	601	12800	8
1965	Oct.	31.0	481	9320	14	3490	25550	1740	607	9580	231	787	9750	334	1666	1750	1660	2160	41800	66
	Nov.	30.0	40	58	31	17200	19100	14500	5540	6400	4370	597	683	531	1719	1730	1710	185	267	144
	Dec.	31.0	36	75	31	18700	21000	14950	6220	7300	4560	607	1100	534	1724	1730	1710	168	348	145
1966	Jan.	31.0	28	40	22	18900	22000	13700	6310	7790	4040	471	653	332	1725	1740	1710	129	185	103
	Feb.	28.0	43	200	28	15100	21750	4540	4625	7670	8740	533	1480	[illegible]	1721	1740	1670	197	906	131
	Mar.	31.0	44	344	24	13500	22000	2560	3960	7790	495	471	1810	234	1705	1740	1660	204	1560	112
	Apr.	30.0	24	54	16	22200	24400	17250	7890	8440	5580	[illegible]	1010	361	1738	1750	1720	111	253	75
	May	31.0	13	24	7	24200	27250	22000	8890	13500	7790	311	524	183	1745	1760	1740	61	113	33
	June	30.0	6.9	15	2.8	26200	34750	13600	9920	14700	4540	184	475	82	1753	1790	1710	33	70	13
	July	31.0	22	379	1.1	12400	38650	6450	3520	17000	1580	212	1770	2.8	1700	1800	1680	102	1730	0.5
	Aug.	31.0	113	1400	3.3	5760	32250	3000	1520	13300	4920	463	1860	85	1679	1780	1660	511	6280	16
	Sept.	30.0	241	1600	24	5350	19200	3170	1100	6450	531	715	3570	379	1673	1730	1670	1087	7200	111
SUMMARY		365.0	92	9320	1.1	7440	38650	1740	1730	17000	231	427	[illegible]	2.8	1681	1800	1660	415	41700	0.5

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: Red FWPCA Station Number: 5 Remarks:

Stream and Location: **Elm Fork of North Fork Red River near Mangum, Oklahoma**
Lat. 34°56', long 99°30', on east line Sec. 10, T.5 N., R.22 W.
at bridge on U. S. Highway 283, 3 miles north of Mangum, 5 miles
downstream from Haystack Creek, and at mile 17.8.

		Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO_4)					
			Cubic Feet/Second			Micromhos/Centimeter^2 @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
Year	Month		Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1966	Oct.	31.0	27	72	17	17700	23400	8290	5810	8260	2240	429	449	370	1540	1670	1240	114	241	76
	Nov.	30.0	19	20	17	23800	25000	23000	8430	8970	8080	430	459	370	1680	1700	1660	86	87	76
	Dec.	31.0	19	24	13	23700	26000	22500	8400	9420	7860	439	566	299	1680	1720	1650	88	109	59
1967	Jan.	31.0	20	26	14	23500	26100	20200	8190	9470	6860	446	601	261	1670	1720	1600	91	118	60
	Feb.	28.0	15	18	13	25000	27000	23600	8970	9880	8340	360	457	299	1700	1740	1670	68	83	59
	Mar.	31.0	16	37	12	25400	30100	18500	9150	11300	6150	397	1130	303	1710	1790	1560	74	179	56
	Apr.	30.0	227	2980	12	6100	29000	2070	1520	10800	392	931	15700	320	1140	1770	840	698	7390	56
	May	31.0	129	2520	12	6920	23500	3010	1790	8300	6280	624	8290	260	1180	1670	934	412	7340	54
	June	30.0	52	648	3.4	9450	25900	3930	2640	9380	878	372	2690	83	1290	1720	1010	181	1990	16
	July	31.0	308	4400	5.4	4500	18100	2530	1040	5980	505	863	8910	72	1050	1550	889	871	11500	22
	Aug.	31.0	12	31	4.1	21200	28000	14900	7490	10300	4680	244	445	103	1620	1760	1470	54	124	19
	Sept.	30.0	126	1530	7.5	6480	25000	2680	1650	8970	543	561	4170	136	1160	1700	904	395	4290	32
SUMMARY		365.0	81	4400	3.4	8100	30100	2070	2180	11300	392	478	15700	72	1240	1790	840	272	11500	16
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
	Apr.																			
	May																			
	June																			
	July																			
	Aug.																			
	Sept.																			
SUMMARY																				

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Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 490 Remarks:

Stream and Location: **North Fork of Red River near Headrick, Oklahoma**
Lat. 34°38', long. 99°06' in center of N½, Sec. 21, T.2 N.,
R.18 W at bridge on U. S. Hwy 62, 2½ mi. east of Headrick,
Jackson County, Oklahoma, and at river mile 33 above mouth.

			STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO_4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
Year	Month	Number of Days of Specific Conductance Record	Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
	Oct.																			
	Nov.																			
	Dec.																			
	Jan.																			
	Feb.																			
	Mar.																			
	Apr.																			
	May																			
	June																			
1960	July	24.0	502	5380	22	2160	10100	1570	411	2820	258	662	3810	147	261	1220	190	421	2800	72
	Aug.	30.4	79	647	12	5250	7390	2710	1240	1900	521	260	2610	45	635	894	328	133	1280	22
	Sept.	2.5	45	219	12	6090	6520	5820	1480	1610	1390	220	333	156	737	789	704	110	163	79
SUMMARY		57.4	209	5380	12	2620	10100	1570	535	2820	258	428	3810	45	316	1220	190	253	2800	22
1960	Oct.	31.0	2310	19000	12	1520	10600	945	246	3020	134	1530	8220	64	183	1280	114	1140	6730	30
	Nov.	30.0	277	670	156	4900	6990	450	1120	1760	710	832	1280	510	591	843	416	441	752	271
	Dec.	31.0	414	1160	155	3860	6740	2350	820	1680	432	916	1560	692	467	813	284	520	934	338
1961	Jan.	31.0	325	506	210	4220	6310	3400	919	1550	596	804	1070	583	504	761	411	445	594	319
	Feb.	28.0	377	611	209	3730	7090	2170	785	1800	390	797	1320	279	450	855	262	458	660	185
	Mar.	31.0	332	1140	101	3870	7520	2450	824	1940	437	736	2100	400	466	907	295	418	1220	227
	Apr.	30.0	237	529	80	4180	8160	2510	910	2150	472	591	1060	364	504	984	303	322	589	193
	May	31.0	181	820	61	4080	9350	2230	880	2560	404	430	1290	215	493	1130	270	241	786	122
	June	30.0	2030	11000	52	1730	7500	1010	292	1930	146	1600	7420	272	210	905	123	1140	5510	128
	July	31.0	217	1220	58	3600	6590	1910	751	1630	331	439	2160	204	436	795	231	255	757	105
	Aug.	31.0	122	945	48	3740	9640	800	787	2670	108	259	[illegible]	115	452	1160	97	148	378	92
	Sept.	30.0	249	2790	42	2660	7750	1310	508	2010	204	341	[illegible]	137	321	935	158	215	1190	88
SUMMARY		365.0	589	19000	12	2430	10600	800	466	3020	108	741	8220	64	300	1280	97	477	6730	30

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 490 Remarks:

Stream and Location: **North Fork of Red River near Headrick, Oklahoma**
Lat. 34°38', long. 99°06' in center of N½, Sec. 21, T.2 N.,
R. 18 W at bridge on U. S. Hwy 62, 2½ mi. east of Headrick,
Jackson County, Oklahoma, and at river mile 33 above mouth.

		Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO4)					
			Cubic Feet/Second			Micromhos/Centimeter @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
Year	Month		Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1961	Oct.	31.0	259	3070	40	1840	7080	393	314	1790	43	219	870	82	221	854	48	154	696	74
	Nov.	30.0	534	5660	73	1830	6600	885	312	1640	124	449	2000	220	220	796	107	317	1720	116
	Dec.	31.0	150	182	105	7010	7920	5500	1770	2070	1290	717	1020	473	847	955	663	343	470	230
1962	Jan.	31.0	125	238	51	7280	8980	5990	1860	2430	1440	624	1010	278	878	1080	722	295	495	129
	Feb.	28.0	66	99	49	7930	9020	7000	2080	2450	1770	368	517	291	956	1090	844	170	243	132
	Mar.	31.0	49	55	40	8710	9350	7460	2340	2590	1920	306	339	254	1050	1130	900	138	153	114
	Apr.	30.0	279	3930	39	4470	10500	2530	992	2980	477	746	7440	251	541	1270	306	407	4350	112
	May	31.0	220	2000	40	3940	11600	1020	841	3390	147	499	1600	177	476	1400	123	283	1140	125
	June	30.0	2480	10300	151	1650	4060	1000	275	874	144	1840	6650	315	200	490	121	1330	4970	200
	July	31.0	194	2090	36	3990	10200	1790	855	2870	304	448	4260	170	482	1230	216	253	2470	86
	Aug.	31.0	250	2470	18	3250	10300	1560	657	2910	255	443	5290	108	392	1240	189	266	3030	49
	Sept.	30.0	517	3890	18	2330	10200	1250	428	2870	193	596	4230	99	282	1230	151	392	2820	47
SUMMARY		365.0	427	10300	18	2630	11600	393	499	3390	43	570	7440	82	317	1400	48	362	4970	47
1962	Oct.	31.0	162	869	50	3740	8300	930	847	2290	149	370	1420	210	656	1060	405	287	949	137
	Nov.	30.0	74	175	51	8070	9050	5300	2212	2550	1310	441	796	348	1040	1130	796	208	425	154
	Dec.	31.0	77	127	61	7660	8600	6100	2070	2400	1560	429	680	354	1010	1090	867	208	336	170
1963	Jan.	31.0	44	82	12	8400	9700	6500	2330	2780	1690	275	560	59	1070	1190	903	127	249	32
	Feb.	28.0	175	415	68	4920	9300	3150	1190	2640	684	564	835	[illegible]07	762	1150	604	360	695	191
	Mar.	31.0	154	445	50	4880	8800	3100	1180	2460	670	491	1170	269	758	1110	599	315	837	140
	Apr.	30.0	56	257	28	8040	11000	2500	2200	3260	512	332	526	157	1040	1310	546	157	409	94
	May	31.0	185	4270	14	2320	11000	1080	467	3260	180	233	2070	102	530	1310	419	264	4820	46
	June	30.0	681	3000	21	1860	6500	1100	354	1690	184	650	2940	63	488	903	420	896	3980	51
	July	31.0	18	127	0.5	5530	10200	1500	1380	2960	271	66	280	3.3	817	1230	456	39	183	1.5
	Aug.	31.0	4.4	27	0	6190	9000	0	1590	2540	--	19	133	0	876	1130	--	10	68	0
	Sept.	30.0	60	656	0	4380	8800	0	1030	2460	--	166	1140	0	714	1110	--	114	1140	0
SUMMARY		365.0	140	4270	0	3740	11000	0	846	3260	--	319	2940	0	656	1310	--	247	4820	0

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red**　　FWPCA Station Number: 490　　Remarks:

Stream and Location: **North Fork of Red River near Headrick, Oklahoma**
Lat. 34°38', long. 99°06' in center of N½, Sec. 21, T.2 N.,
R. 18 W at bridge on U. S. Hwy 62, 2½ mi. east of Headrick,
Jackson County, Oklahoma, and at river mile 33 above mouth.

			STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO₄)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
		Number of Days of Specific Conductance Record		Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
Year	Month		Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1963	Oct.	31.0	68	1470	0	1220	9400	0	243	2780	--	45	441	0	203	1060	--	37	474	0
	Nov.	30.0	20	65	6	10500	14000	8300	3170	4480	2390	174	746	41	1160	1460	956	63	247	16
	Dec.	31.0	14	21	5	13300	14500	10200	4200	4660	3060	160	263	60	1400	1500	1130	53	85	20
1964	Jan.	31.0	13	21	5	14600	16500	12000	4700	5430	3720	167	277	70	1510	1670	1290	54	86	22
	Feb.	29.0	165	1270	20	3940	13000	1360	984	4090	277	437	1270	220	524	1370	222	232	906	74
	Mar.	31.0	28	39	22	13000	15200	11200	4090	4930	3420	307	410	224	1370	1560	1220	103	135	77
	Apr.	30.0	13	22	8.4	14600	17500	10500	4700	5830	3170	170	286	105	1510	1750	1160	55	91	34
	May	31.0	138	930	7.1	4140	15500	2130	1040	5040	472	387	2410	72	545	1580	319	203	1290	25
	June	30.0	307	3220	24	3490	13800	1300	852	4390	262	704	9370	189	475	1440	214	393	4840	72
	July	31.0	5	35	0	8900	11000	0	2600	3350	--	35	254	0	1010	1200	--	14	98	0
	Aug.	31.0	4.5	47	0	5330	8650	0	1410	2520	--	17	179	0	669	989	--	8	76	0
	Sept.	30.0	60	307	0	4070	9300	0	1020	2740	--	166	1060	0	538	1050	--	87	458	0
SUMMARY		366.0	69	3220	0	4620	17500	0	1190	5830	--	221	9370	0	596	1750	--	111	4840	0
1964	Oct.	31.0	8.3	41	0.1	9540	17300	3790	2880	6420	833	64	637	0.8	980	1320	619	22	131	0.3
	Nov.	30.0	193	1200	12	3650	12500	1580	786	4150	257	409	3260	134	605	1120	400	315	2000	36
	Dec.	31.0	38	50	16	11600	13100	[illegible]	3750	4420	2360	385	593	188	1080	1150	910	111	154	49
1965	Jan.	31.0	32	38	26	12200	13000	10900	4010	4370	3450	342	411	274	1110	1140	1050	95	113	77
	Feb.	28.0	27	35	10	12500	13700	11200	4145	4690	3580	301	360	107	1122	1170	1060	81	102	30
	Mar.	31.0	25	39	19	13000	14200	12100	4370	4920	3970	299	448	239	1144	1200	1100	78	119	61
	Apr.	30.0	77	615	21	8110	13800	3170	2320	4740	655	480	4630	241	904	1180	566	187	1600	64
	May	31.0	108	822	22	5200	10700	1960	1274	3360	343	371	3810	163	724	1040	445	211	1610	58
	June	30.0	702	4400	28	2550	9570	1670	489	2890	277	925	6810	184	508	982	411	961	6380	72
	July	31.0	33	123	5.2	7500	12000	2750	2085	3920	541	183	374	49	869	1100	527	76	174	15
	Aug.	31.0	4.5	18	0.3	9380	12600	6220	2817	4190	1620	34	146	2.1	972	1130	792	12	39	0.8
	Sept.	30.0	1675	14200	0.2	1100	11200	573	158	3580	66	713	[illegible]	1.6	334	1060	241	1508	10500	0.5
SUMMARY		365.0	241	14200	0.1	2535	17300	573	485	6420	66	315	6810	0.8	506	1320	241	329	10500	0.3

Appendix E (Cont'd)

MONTHLY SUMMARY OF CONTINUOUS RECORDED FLOW AND QUALITY DATA

River Basin: **Red** FWPCA Station Number: 490 Remarks:

Stream and Location: **North Fork of Red River near Headrick, Oklahoma**
Lat. 34°38', long. 99°06' in center of N½, Sec. 21, T.2 N.,
R.18 W at bridge on U. S. Hwy 62, 2½ mi. east of Headrick,
Jackson County, Oklahoma, and at river mile 33 above mouth.

		Number of Days of Specific Conductance Record	STREAM FLOW			SPECIFIC CONDUCTANCE			CHLORIDES (Cl)						SULFATES (SO4)					
			Cubic Feet/Second			Micromhos/Centimeter² @ 25° C			Milligrams/Liter			Tons/Day			Milligrams/Liter			Tons/Day		
				Extremes			Extremes			Extremes			Extremes			Extremes			Extremes	
Year	Month		Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day	Wt. Mean	Max. Day	Min. Day
1965	Oct.	31.0	1252	17700	70	2040	10450	790	448	3080	146	1510	12000	498	568	1040	498	1917	25000	183
	Nov.	30.0	142	192	99	8840	10500	7700	2530	3100	2150	968	1130	811	948	1040	884	363	460	278
	Dec.	31.0	144	1100	86	6990	10500	2560	1920	3100	585	745	1730	670	845	1040	597	328	1770	234
1966	Jan.	31.0	88	195	50	9000	10300	7880	2580	3030	2210	614	1350	365	957	1030	894	228	503	132
	Feb.	28.0	153	687	60	6790	10000	2080	1850	2920	458	763	2650	379	834	1010	570	344	1410	155
	Mar.	31.0	121	584	60	6400	11600	2160	1730	3480	479	564	2440	248	812	1100	575	265	1160	153
	Apr.	30.0	57	132	19	9880	12000	7150	2880	3620	1970	444	1090	185	1006	1130	854	155	368	58
	May	31.0	39	100	18	10950	12400	7890	3250	3770	2210	343	739	176	1066	1150	895	113	253	55
	June	30.0	10	48	3.6	11100	13000	6800	3310	3980	1850	92	239	31	1074	1180	834	30	107	10
	July	31.0	5.6	65	0	9990	12200	--	2920	3700	--	44	537	0	1012	1140	--	15	172	0
	Aug.	31.0	139	1430	0	2840	10500	--	662	3100	--	248	1760	0	613	1040	--	230	2200	0
	Sept.	30.0	268	950	25	3570	9330	1430	867	2690	294	626	2810	123	654	976	534	472	1760	66
SUMMARY		365.0	203	17700	0	4080	13000	--	1020	3980	--	558	12000	0	682	1130	--	373	25000	0
1966	Oct.	31.0	58	284	23	8190	14800	1070	2130	4730	136	333	412	104	1050	1190	668	164	510	73
	Nov.	30.0	25	26	21	15500	16000	[illegible]	5040	5260	4780	338	367	297	1210	1210	1200	81	85	68
	Dec.	31.0	20	29	11	16500	17000	15000	5480	5710	4820	290	444	142	1220	1230	1200	65	96	35
1967	Jan.	31.0	24	53	13	14500	18000	6960	4600	6170	1710	292	751	1.5	1190	1250	1010	75	135	41
	Feb.	28.0	25	35	21	15700	17300	12300	5130	5850	3690	350	385	322	1210	1240	1150	62	108	69
	Mar.	31.0	17	30	0	17600	19400	--	5980	6830	--	266	440	[illegible]	1240	1270	--	55	98	0
	Apr.	30.0	391	3970	8.9	4400	17400	2010	918	5890	318	968	16400	136	913	1240	768	962	8450	29
	May	31.0	141	1120	1.1	5100	12600	2790	1120	3810	496	425	4470	11	943	1150	826	358	2970	3.4
	June	30.0	116	602	0	6730	12200	--	1630	3650	--	512	3530	0	1000	1140	--	315	1700	0
	July	31.0	349	2960	1.9	3950	8650	2440	794	2290	414	747	6010	8.1	891	1060	802	839	7030	5.1
	Aug.	31.0	14	33	0.9	11030	14200	8480	3180	4480	2230	123	255	6.5	1120	1180	1055	43	94	2.6
	Sept.	30.0	174	947	0	5540	13000	--	1250	177	--	589	[illegible]	0	961	698	--	452	2120	0
SUMMARY		365.0	113	3970	0	5850	19400	--	1350	6830	--	411	16400	0	[illegible]	1270	--	296	8450	0

Appendix F

SODIUM-ADSORPTION RATIOS

The sodium adsorption ratios or SAR's were determined for both existing and controlled conditions of Area VI using the procedure set forth in "Diagnosis and Improvement of Saline and Alkali Soils" by U. S. Salinity Laboratory Staff, U. S. Department of Agriculture on page 72. The SAR's for existing conditions were calculated using correlations between chloride concentrations and specific conductance; controlled conditions were determined using a correlation between total dissolved solids and specific conductance as determined in the "Arkansas-Red River Basin Water Quality Conservation" - Appendix Volume III - Water Quality Data by the U. S. Public Health Service, page 178. The SAR's were determined by using the estimated cumulative mean chloride and sulfate concentrations to determine the various concentrations of calcium, magnesium, and sodium. Using cations concentration in the formula

$$SAR=Na^{+}/\sqrt{Ca^{++}+Mg^{++})/2}$$

where Na^{+}, Ca^{++}, and Mg^{++} represent the concentration in milliequivalents per liter of the respective ions.

Conductivity

Low-salinity water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-salinity water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very high salinity water (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

Sodium

The classification of irrigation waters with respect of SAR is based primarily on the effect of exchangeable sodium on the physical condition of the soil. Sodium-sensitive plants may, however, suffer injury as a result of sodium accumulation in plant tissues when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of soil.

Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

Medium-sodium water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management - good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

Very high sodium water (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments make the use of these waters feasible.

Sometimes the irrigation water may dissolve sufficient calcium from calcareous soils to decrease the sodium hazard appreciably, and this should be taken into account in the use of C1-S3 and C1-S4 waters. For calcareous soils with high pH values or for non-calcareous soils, the sodium status of waters in classes C1-S3, C1-S4, and C2-S4 may be improved by the addition of gypsum to the water. Similarly it may be beneficial to add gypsum to the soil periodically when C2-S3 and C3-S2 waters are used.